EFFICACY OF LATIN DANCE AS A HEALTH-ENHANCING LEISURE ACTIVITY FOR ADULTS

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A thesis submitted to Kingston University in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Ph.D.)

March 2015

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DECLARATION

I confirm i) that while registered as a Ph.D. candidate at Kingston University, I have not been enrolled as a student at any other institution of higher education, ii) that this thesis does not contain any material that has been previously submitted for an academic award, and iii) that this work is solely the result of my own efforts, except where acknowledged.

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ABSTRACT

Despite acceptance that physical activity serves as a protective agent against the burden of non-communicable disease, half of all adults in the developed world remain insufficiently physically active. The promotion of physical activity is therefore of paramount importance to public health researchers and practitioners. Dance, as a leisure or social activity, can play a role in the engagement of adults in physically active pursuits that are not necessarily thought of as traditional exercise per se. This is especially important for those individuals not currently meeting physical activity guidelines and is fully congruent with the current public health message that "some activity is better than none". A holistic exploration of Latin dance was undertaken in this thesis in the context of physical activity and psychosocial health promotion in non-clinical adults. The research encompassed a quantitative assessment of physiological and psychological measures related to dance. Over a 3 yr period, eighty-four women and men were enrolled in a series of four interrelated Latin dance (salsa) and Latin-themed aerobic dance (Zumba fitness) studies. Research grade motion sensing and heart rate monitors were used to evaluate the physiological responses to dance, and a novel activity-specific value calibration method was developed to process the data. The monitors, which are small and unobtrusive to wear, were then utilised for collection of data during performance of dance in naturalistic settings. Psychological measures associated with dance participation were captured using previously validated questionnaires. Results indicate that Latin dance elicits physiological responses representative of moderate to vigorous physical activity when performed primarily for leisure purposes. Modest improvements were observed post-dance in measures of cardiorespiratory fitness, body composition, and inflammatory biomarkers in relation to cardiovascular health. Moreover, participation fostered interest, enjoyment, and a positive psychological outlook, and enhanced well-being, mood, and health-related quality of life with large magnitude effects. The findings of this thesis may be relevant for researchers and practitioners interested in the efficacy of dance as an expressive and creative medium for the promotion of physical and mental health.

JOURNAL PUBLICATIONS

Some of the content within this thesis has been published as articles in the following peer-reviewed scientific journals:

- Domene PA, Easton C. Combined triaxial accelerometry and heart rate telemetry for the physiological characterization of Latin dance in non-professional adults. *J Dance Med Sci.* 2014;18:29–36 (presented in Chapter 4).

- Domene PA, Moir HJ, Pummell E, Easton C. Physiological and perceptual responses to Latin partnered social dance. *Hum Mov Sci.* 2014;37:32–41 (presented in Chapter 5).

- Domene PA, Moir HJ, Pummell E, Easton C. Salsa dance and Zumba fitness: acute responses during community-based classes. *J Sport Health Sci.* 2015. Epub ahead of print (presented in Chapter 6).

CONFERENCE PRESENTATIONS

Some of the content within this thesis has been presented in poster format at the following scientific conferences:

- Combined triaxial accelerometry and heart rate telemetry for the physiological characterisation of Latin dance. *American College of Sports Medicine* annual meeting held 28 May – 1 June 2013 (Indianapolis, IN, USA).

- Physiological and psychological responses to Latin partner-based social dance. *The British Association of Sport and Exercise Sciences* annual meeting held 3 – 5 September 2013 (Preston, UK).

- Salsa dance and Zumba fitness: acute responses during community-based classes. *American College of Sports Medicine* annual meeting held 27 – 31 May 2014 (Orlando, FL, USA).

ACKNOWLEDGEMENTS

Firstly, to all of my participants who kindly gave up their time to volunteer for this research, thank you, sincerely, as this work could not have been completed without your assistance. Thank you, also, to all of my supervisors and colleagues for providing me with the guidance that you did over the course of my studies. And lastly, I need to mention, of course, the unconditional support I received from all of my family and friends whilst here at Kingston – thank you so much.

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ABBREVIATIONS

ANK	Vector Magnitude Acceleration of the Ankle
ANOVA	Analysis of Variance
BF	Percent Body Fat
BM	Body Mass
BMI	Body Mass Index
BP	Blood Pressure
CI	Confidence Interval
CRP	C-Reactive Protein
EBBS	Exercise Benefits/Barriers Scale
EE	Energy Expenditure
EI	Energy Intake
ELISA	Enzyme-Linked Immunosorbent Assay
HDL-C	High-Density Lipoprotein Cholesterol
HIP	Vector Magnitude Acceleration of the Hip
HR	Heart Rate
HR_{max}	Maximal Heart Rate
HRQoL	Health-Related Quality of Life
HRR	Heart Rate Reserve
HRR_{max}	Maximal Heart Rate Reserve
IL-6	Interleukin-6
IM	Intrinsic Motivation
IMI	Intrinsic Motivation Inventory
MET	Metabolic Equivalents
MVPA	Moderate to Vigorous Physical Activity
PA	Physical Activity
PB	Perceived Benefits
PD	Psychological Distress
POMS	Profile of Mood States
POMS-2	Profile of Mood States 2nd Edition Short Form for Adults
PWB	Positive Well-Being
RM-ANOVA	Repeated Measures Analysis of Variance
RM-ANCOVA	Repeated Measures Analysis of Covariance

RPE	Rating of Perceived Exertion
SC	Step Count
SEE	Standard Error of the Estimate
SEES	Subjective Exercise Experiences Scale
SF-36	RAND 36-Item Health Survey 1.0
TC	Total Cholesterol
VCO_2	Carbon Dioxide Output
VE	Pulmonary Ventilation
VM	Vector Magnitude
VO_2	Oxygen Uptake
VO_{2max}	Maximal Oxygen Uptake
WBC	White Blood Cell Count
WHO	World Health Organization
WRI	Vector Magnitude Acceleration of the Wrist

1 GENERAL INTRODUCTION

Non-communicable diseases are the leading cause of mortality in high-income countries.[1] Elevated blood pressure (BP; hypertension), glucose (type two diabetes), and cholesterol (dyslipidaemia), and excess weight gain (obesity) are known to be strongly influenced by several behavioural risk factors: harmful consumption of alcohol; smoking of cigarettes; poor dietary intake; and lack of physical activity (PA).[1] PA has been defined as bodily movement produced by skeletal muscles resulting in energy expenditure (EE), whereby the EE is measurable in kilocalories.[2] The benefits of regular PA are firmly established in terms of a reduced risk for the major non-communicable diseases currently threatening global health.[3] Of concern to PA investigators is the fact that half of the adult populace remains insufficiently physically active[1]; the promotion of PA, therefore, is of paramount importance to both public health researchers and practitioners.

Dance, when performed socially or for leisure, could potentially be a viable way of engaging more individuals in PA,[4] as dance itself is generally not perceived to be actual exercise per se. Furthermore, as enjoyment, social interaction, and the health-related aspects of PA are known to be the main reasons for adult participation in leisure physical pursuits,[5] recreational social dancing may have potential as a form of activity for the enhancement of physical and psychosocial health. PA type is also an important consideration in the selection of a health-oriented leisure pursuit, as long-term adherence is likely maintained only when participation is perceived to be enjoyable,[6] offers opportunity for skill mastery, fosters a self-regulated experience, and provides a sense of connectedness with others.[7] Social dance, arguably, addresses each of these elements of the self-determination theory[7] well.

Dance has been identified as human behaviour composed, from the dancer's perspective, of purposeful, intentionally rhythmical, and culturally patterned sequences of non-verbal body movement commonly performed to

music.[8] Participation in dance inherently involves simultaneous somatic, emotional, and cognitive challenges.[9] Current literature indicates dance involvement offers a multitude of auditory, visual, and kinesthetic stimuli, often within an environment that fosters social interaction, musical experience, emotional expression, and memory and motor skill development.[10] It is these characteristics that make dance an enriched activity. Additionally, dance engagement has been shown to improve self-esteem and physical self-perceptions, increase confidence, and promote positive thoughts and feelings when taken part in as a (non-competitive) leisure or social activity.[11] Accordingly, dance is recommended as an example health-enhancing leisure PA by: the World Health Organization (WHO) in the 2010 publication Global Recommendations on Physical Activity for Health[12]; the UK Department of Health in the 2011 publication Start Active, Stay Active: A Report on Physical Activity From the Four Home Countries' Chief Medical Officers[13]; and the USA Department of Health and Human Services in the 2008 publication Physical Activity Guidelines for Americans.[14] Moreover, dance (including aerobic dance) is the fourth most prevalent leisure PA engaged in by women in the UK.[15] In the USA, similarly, aerobic dance and dance are the second and third most prevalent forms of PA, respectively, that women take part in during their leisure time.[16] However, despite dance intuitively being a potentially efficacious activity in terms of the promotion of physical and mental health, especially for those who are insufficiently physically active, there is a dearth of information in the dance literature to substantiate its purported health-enhancing efficacy in non-clinical adults; much of the existing research has focussed on adolescent[17] or older adult[18] age groups and in individuals with clinical conditions, such as mental illness,[19] dementia,[20] depression,[21] or type two diabetes.[22]

As a form of socialisation and for leisure purposes, dance has long played an important role in Latin culture for individuals of all ages and for both sexes.[23] Although numerous styles of dance within the Latin genre exist today, one of the most popular for recreational social dancing, in both Latin and non-Latin communities, is salsa.[24] Salsa is commonly performed as a partnered social dance between a man, who leads the dance, and a woman, who follows.[24,25] It has recently been suggested by PA investigators that this genre

of dance may have potential in terms of the promotion of physical[26] and psychosocial[27] health in adults. Similarly, research interest in non-partnered Latin-themed aerobic dance (Zumba fitness) has also increased in recent years, likely a result of the gaining popularity of the various styles of Latin rhythms and dance within the mainstream dance and fitness audiences.[28] It has been reported that Zumba fitness is practised regularly by millions of aerobic dancers[29] and is currently the world's largest branded fitness programme.[30] It has also been reported that females constitute ~96% of individuals regularly engaging in aerobic dance for fitness purposes.[15]

Researchers and practitioners interested in the efficacy of dance as an expressive and creative medium for the promotion of health may find the presented work relevant, especially given that organisations in both the health and arts sectors continue to seek practical and sustainable ways of enhancing physical and mental health in the general adult population.[4,31] Increasing our scientific knowledge regarding the efficacy of dance-oriented activities would likely be of use in the design of future strategies aimed at reducing the burden of physical and psychological ill health through non-traditional modalities, such as dance. To that end, a holistic exploration of Latin dance (salsa) and Latin-themed aerobic dance (Zumba fitness) was undertaken in this research in the context of PA and psychosocial health promotion in non-clinical adults.

2 LITERATURE REVIEW

2.1. PA promotion for physical and mental health

Population levels of PA have been declining in recent decades in the developed world[32] and currently half of all adults fail to meet recommended PA guidelines[12] for the maintenance of physical and mental health.[1] The beneficial effects of regular PA are convincing and well-established in the literature.[12,33,34] In the adult populace, strong evidence exists to indicate that PA reduces all-cause mortality, hypertension, coronary heart disease, stroke, type two diabetes, metabolic syndrome, breast and colon cancer, and depressive- and anxiety-related disorders.[12,35,14] Moreover, evidence also demonstrates that PA is beneficial for improved cardiorespiratory fitness, musculoskeletal and functional health, body mass (BM) and composition, and cognitive functioning.[12,14,35] PA promotion is therefore of paramount importance to investigators of public health.

Worldwide, it has been estimated that physical inactivity is responsible for 10, 10, 7, and 6% of the total burden of disease from breast cancer, colon cancer, type two diabetes, and coronary heart disease, respectively.[3] Physical inactivity is attributable for 9% of the world's premature mortality, and elimination of this behaviour would be expected to increase worldwide life expectancy by 0.68 yr.[3] It was recently reported that physical inactivity has become as much of a risk factor for early death as smoking and obesity.[3] PA guidelines published by the WHO[12] and the governments of the UK[13] and the USA[14] recommend adults (aged 18 to 64 yr) accrue at least 150 min of moderate or 75 min of vigorous intensity aerobic PA per week in bouts of at least 10 min. To date, more than one hundred epidemiological studies have assessed the relationship between PA and mortality risk; taken together, the benefits of engagement in PA clearly outweigh the risks involved[36] in the general adult population. It should be noted that moderate to vigorous aerobic

PA not only encompasses organised exercise and sports (i.e., running and cycling), but also refers to some leisure or recreational (i.e., walking and dancing) and some daily living (i.e., gardening and housework) activities.[12,13,14]

There has been growing interest in recent years in the health psychology literature regarding the association between PA and psychological well-being. A meta-analytic systematic review reported that well-being was associated with reduced mortality in 36,000+ healthy individuals.[37] Howell and colleagues,[38] also using meta-analytic techniques, demonstrated that well-being positively impacted long-term health outcomes in 34,000+ individuals. A recent literature review described PA as an efficacious strategy for the enhancement of psychological well-being, in part, due to the relationship between PA and positive affect.[39] Moreover, much cross-sectional evidence supports the fact that PA correlates with indicators of improved mental health. Steptoe and colleagues[40] reported a relationship between PA and decreased depression in 16,000+ young adults after adjustment for age and sex. In 10,000+ university alumni followed for ~25 yr, it was demonstrated that PA and depression were negatively associated.[41] A secondary survey analysis of 55,000+ people indicated that participation in PA, after adjustment for age, sex, sociodemographic status, and illness, was related to decreased anxiety- and depressive-related symptoms.[42] Indeed, evidence strongly suggests that regular PA engagement has salutary effects on both the physical and mental health of adults.

2.2. Cardiovascular health and its relationship with PA and inflammation

Although improved health afforded through PA is currently accepted, the precise cardioprotective mechanisms underlying this relationship remain to be clarified. It has been suggested that the association between PA and increased cardiovascular health can be attributed largely to the positive effects of PA on body mass index (BMI), BP, blood lipids, and inflammation and its clinical biomarkers, such as C-reactive protein (CRP), interleukin-6 (IL-6), and white blood cell count (WBC).[43,44,45] In recent years, inflammatory processes have been increasingly acknowledged as playing a key role in the development of atherosclerosis and its related complications. Inflammation is now considered an established independent risk factor for cardiovascular disease.[46,47]

Moreover, the acute phase reactant CRP, synthesised primarily by the liver in response to IL-6, is thought to be a robust inflammatory predictor of future cardiovascular events.[47] While it has been shown that higher PA and cardiorespiratory fitness correlate with lower circulating CRP,[48] it has also been put forth that the relationship between PA volume/intensity and improved inflammatory biomarkers is modulated, at least in part, by adiposity.[49]

Okita and colleagues[50] examined one hundred ninety-nine overweight women before and after two months of participation in supervised PA involving twice weekly aerobic dance classes. Both WBC and CRP decreased; however, it was noted that the improvement in CRP was not proportionally associated with the extent of weight reduction. Although the authors suggested that this may have resulted from the training stimulus being too high, it is difficult to draw conclusions based on the intensity of the dance sessions as objective measurement of PA was not recorded. In a prospective cohort analysis of 27,000+ women followed for ~11 yr, the risk of cardiovascular incident was shown to decrease with increasing PA levels.[43] The largest single contributor to the lowered risk was inflammatory/hemostatic biomarkers (i.e., CRP and fibrinogen). Similarly, in a nationally representative sample comprising 7000+ adults followed over a ~7 yr period, it was reported that the inverse relationship between PA and cardiovascular risk was mediated largely by BP and inflammatory/hemostatic factors.[51]

After adjustment for age, race, sex, BMI, and smoking and health status, King and colleagues[45] reported a lowered likelihood of elevated CRP, WBC, and fibrinogen in 4000+ adults who engaged in aerobic dance, when compared with traditional modalities of exercise, such as cycling, swimming, and weight training. These analyses were performed on the Third National Health and Nutrition Examination Survey data set, a stratified cluster sample of the 1988 – 1994 USA population, and provided initial support to suggest that different forms of PA may result in varying responses in the inflammatory processes relevant to cardiovascular health. In line with these findings, Chen and colleagues[52] recently examined 15,000+ adults and reported dance and tai chi to be more favourably associated (fully adjusted statistical model) with a lowered risk of hypertension, dyslipidaemia, hyperglycaemia, and obesity development in comparison with other forms of PA and exercise. Although

inflammatory biomarkers were not assessed in this research, taken together, the evidence suggests it would seem prudent to engage regularly in PA that is conducive to the improvement of all cardiovascular health-related risk factors.

2.3. Dance-based PA research: evidence for physical and mental health enhancement

A need exists for identifying efficacious methods of accumulating moderate to vigorous physical activity (MVPA) in various adult populations, especially for the physically inactive and in the broader context of psychosocial health-oriented research. Social dancing for recreational purposes has the potential to be a sustainable and effective leisure activity given that enjoyment, social interaction, and the health-related aspects of PA, all factors that social dance is positioned well for, have been identified as the primary reasons why both younger and older adults choose to engage in physical pursuits during their leisure time.[5]

Substantial evidence exists to support the notion that dance participation confers a wide range of physical and mental health benefits in adults of all ages. Four weeks of moderate intensity dance-based exercise (50 min sessions twice weekly) resulted in favourable physiological responses in physically inactive pre-hypertensive adults.[53] No changes were demonstrated in a control group. Thirty-eight individuals completed the study, which resulted in increased maximal oxygen uptake (VO_{2max}) and decreased BP post-intervention. Granacher and colleagues[54] reported improved static and dynamic postural control for intervention participants, when compared with controls, following a dance programme of 8 wk in duration. In this study, twenty-eight older adults took part in 1 h classes of dance twice weekly. Engagement in dance was reported to be safe, enjoyable, and beneficial as a modality of non-traditional exercise; however, it was noted that dance was ineffective for increasing lower limb muscular power. In another study, physical performance of older women (n = 20) was enhanced following a 6 wk dance programme performed three times weekly (40 min sessions).[55] No improvement was reported in a control group. Evaluated outcomes were cardiovascular endurance, lower limb muscular strength, and hamstring and low back flexibility, all of which demonstrated clinically significant improvements post-intervention. These findings are consistent with the results of other dance-

related exercise studies,[56,57] lending support to the notion that dance may indeed be viable as a legitimate modality of PA in non-clinical adults.[31,58]

In a 12 wk intervention, Mastura and colleagues[59] assessed the mental health effects of dance participation in physically inactive overweight women. The treatment group (n = 20) undertook 1 h sessions of dance three times weekly and improved in measures of psychological stress post-intervention more so than those assigned to a control condition. Psychological stress was evaluated using the Derogatis Stress Profile. Acute psychological stress and affect were also investigated in a dance-based study conducted by West and colleagues.[60] The Positive Affect and Negative Affect Schedule and Perceived Stress Scale instruments were administered to a sample of apparently healthy young adults (n = 21) before and after attendance in 90 min sessions of dance. A reduction in psychological stress and negative affect, and an increase in positive affect, were reported.

2.4. Psychological evaluation of dance: mood, IM, PWB, PD, PB, and HRQoL

Acute mood change following a 1 h session of aerobic dance was investigated using the Profile of Mood States (POMS) in apparently healthy women (n = 75) with previous aerobic dance experience.[61] A cohort of female non-exercisers served as controls. The POMS was administered pre- and post-dance, and improvements in anger, confusion, depression, tension, and vigour were reported. It was noted that the control participants experienced a decrease in vigour and fatigue post-study. The same instrument was also used in an investigation evaluating acute mood change in eighty adults following a 1 h aerobic dance session.[62] Post-dance scores revealed improvements in both the depressed and no-depression groups; however, a greater decrease in anger, confusion, tension, and a greater increase in vigour was evident in the depressed mood group. Favourable results from the two aforementioned studies support the hypothesis that dance does indeed have the potential to improve mood. These findings are consistent with previous studies that have indicated engagement in traditional exercise modalities is effective for mood regulation.[63] No studies to date, however, have evaluated the long-term stability of dance-related enhancements in mood.

Intrinsic motivation (IM) for salsa dance was evaluated in an 11 wk study of recreational dancers (weekly volume of dance not specified).[64] Both intervention (n = 58) and control participants improved in the Intrinsic Motivation Inventory (IMI) dimensions of interest-enjoyment and perceived competence post-dance. Effort-importance remained stable over time in the dance group, but decreased in controls. No change was observed for tension-pressure in either group. From the self-determination perspective,[7] the fulfillment of competence, autonomy, and relatedness needs have been theorised to contribute to IM for PA and its adherence. Interest-enjoyment, perceived competence, and effort-importance positively indicate IM, while, conversely, tension-pressure has been theorised to be a negative indicator of IM.[7] Kim and Kim,[65] using an observational research design without a control condition, assessed changes in positive well-being (PWB), psychological distress (PD), and fatigue following a single 40 min session of aerobic dance. Eighty-four apparently healthy adults were assigned to the aerobic dance group. The Subjective Exercise Experiences Scale (SEES) was administered pre- and post-dance, with post-dance scores revealing improvements in all three subjective experiences assessed. To date, no other health-related investigations of dance have explored IM using the IMI, or PWB and PD using the SEES, in non-clinical adults.

In an investigation of the perceived benefits (PB) of social dance, four hundred seventy-five recreational dancers from different dance genres, including Latin, provided responses to an online administration of the Perceived Benefits of Dancing questionnaire.[66] The 29-item instrument was reported to have satisfactory internal consistency for the dimensions of emotional benefits, well-being and meaningfulness, creativity benefits, and physical benefits. It was revealed that emotional benefits was rated highest by both female and male dancers, and that women perceive greater overall benefits from dance when compared to men. The authors concluded that social dance is thought to be an enjoyable activity that is beneficial physically, socially, and emotionally. To date, this study is the only research to have analysed the PB of social dance in recreational dancers within a health promotion context.

Dance participation has also been posited by PA investigators to have the potential to improve health-related quality of life (HRQoL).[67] In an aerobic dance intervention, fourteen apparently healthy women undertook 1 h sessions of dance twice weekly.[67] The 26-item WHO Quality of Life questionnaire was administered pre- and post-study. This instrument has been reported to have adequate internal consistency for its physical, psychological, social, and environmental dimensions.[68] While no change over time was observed for controls, the dance group improved in their pooled HRQoL score. A large magnitude effect was observed. Although higher levels of PA engagement have been associated with better HRQoL,[69,70] in a review of the literature of the general adult population, only the one aforementioned study specifically tested the hypothesis that dance affects HRQoL in a positive fashion. Aerobic exercise, in general, correlates with modest effects on HRQoL in adults.[69]

2.5. Latin dance for health promotion: research in non-clinical adults

Several popular styles of Latin dance have been selected for use by researchers interested in evaluating the efficacy of dance for improvement of physical and mental health outcomes in adults. Although the number of Latin dance and Latin-themed aerobic dance interventions conducted in non-clinical adults is relatively small, the findings of these investigations,[21,27,67,71,72,73,74,75,76] taken together, suggest that participation in this genre of dance may indeed be health-enhancing. The synthesis of these results supports the proposal that recreational dance is efficacious as an expressive medium for the promotion of health.[31] A summary of the aforementioned research is presented (Table 2.1). In an intervention, physically inactive women undertaking 90 min classes of salsa and merengue three times weekly improved VO_{2max} from pre- to post-dance.[71] No change was observed for control participants. The authors noted that after a six month follow-up, the intervention group was able to maintain almost half of their improvement in cardiorespiratory fitness. As salsa has been shown to elicit moderate to vigorous intensities of PA during laboratory-based,[77] real social,[26,78] and instructor-led group classes of dance,[79,80] it is not surprising that participation in a sufficient volume of dance can improve the physical capacity of non-exercisers.[71] In a study of overweight women, Lee and colleagues[72] reported increased MVPA from pre- to post-intervention following

Table 2.1. Summary of Latin dance interventions conducted in a physical and mental health promotion context in non-clinical adults aged 18 to 64 yr.

Primary author	Dance genre	Cohort	Mean age	Intervention length	Retention	Final sample size	Key outcomes	Potential limitations
Araneta (2014)[76]	Latin-themed aerobic dance (Zumba fitness)	Physically inactive obese women	53 yr	12 wk	81%	Thirteen (no control group used)	Systolic and diastolic BP ↓ by 14 and 6 mmHg, respectively	Only 71% of the intervention sessions were attended
Barene (2013)[74] *	Latin-themed aerobic dance (Zumba fitness)	Healthcare workers	46 yr	12 wk	83%	Thirty intervention and thirty-four control	Cycle ergometer time to exhaustion and power output ↑ by 4 and 6%, respectively	No measures of habitual PA or dietary EI were recorded
Barene (2014)[75] *	Latin-themed aerobic dance (Zumba fitness)	Healthcare workers	46 yr	40 wk	65%	Twenty-five intervention and twenty-five control	VO_{2max} ↑ from 32 to 34 mL/kg/min	All male participants withdrew from the Zumba fitness classes
Birks (2007)[27]	Latin dance (salsa)	Adults with depressive symptoms	39 yr	8 wk	33%	Eight (no control group used)	Depressive symptom severity ↓ (effect size not specified)	Previous Latin dance experience was not accounted for in the inclusion criteria
Donath (2014)[67]	Latin-themed aerobic dance (Zumba fitness)	Female university students	21 yr	8 wk	97%	Fourteen intervention and fifteen control	HRQoL ↑ with a large magnitude effect (partial $\eta^2 = 0.45$)	Participants were already physically active at enrolment, reporting 7.5 h of PA weekly
Federici (2005)[73]	Latin dance (salsa, merengue, and bachata)	Physically inactive older adults	63 yr	13 wk	100%	Twenty intervention and twenty control	Balance ability ↑ by 8%	No laboratory-based measurements were taken
Hovell (2008)[71]	Latin dance (salsa and merengue)	Physically inactive women	31 yr	26 wk	91%	Sixty-eight intervention and sixty-six control	VO_{2max} ↑ from 28 to 33 mL/kg/min	Dietary EI was not recorded
Lee (2011)[72]	Latin dance (salsa, merengue, bachata, and cha-cha-chá)	Overweight women	42 yr	8 wk	82%	Forty-one (crossover design used)	MVPA ↑ from 11 to 34 MET min/wk	Accelerometer-based PA data were not processed using activity-specific techniques

Pinniger (2012)[21]	Latin dance (tango)	Adults with depressive-, anxiety-, or stress-related symptoms	44 yr	6 wk	78%	Twenty-one intervention and twenty-nine control	Depressive- and stress-related symptom severity ↓ with medium (*d* = 0.50) and small magnitude effects (*d* = 0.45), respectively	No follow-up measures were made

BP = blood pressure; EI = energy intake; HRQoL = health-related quality of life; MET = metabolic equivalents; MVPA = moderate to vigorous physical activity; PA = physical activity; VO_{2max} = maximal oxygen uptake; * indicates a single study undertaken in two phases.

engagement in classes of salsa, merengue, bachata, and cha-cha-chá. The 1 h dance sessions were attended twice weekly. Although PA data in this study were collected objectively using accelerometry, the cut-point system chosen for determination of time spent at various PA intensities was not developed specifically for dance. It has since been demonstrated that accelerometer value calibrations performed using standard ambulatory activities are less accurate and precise for the assessment of dance when compared to value calibrations derived using dance-specific methods.[77] In a study of physically inactive older adults, it was revealed that 1 h classes of salsa, merengue, and bachata undertaken twice weekly improved balance in intervention participants.[73] No change was observed in a control group. The reported improvements in balance were similar in magnitude to those previously shown in older adults following engagement in aerobic dance[81] and tai chi,[82] and better than those demonstrated after a home-based exercise programme of strength training and walking.[83]

Using an observational research design, Quiroga Murcia and colleagues[84] evaluated Latin dance in a laboratory-based environment while measuring the acute effects of dance on psychological stress and affect. Twenty-two recreational dancers performed 20 min sessions of tango. The Positive Affect and Negative Affect Schedule was administered and saliva samples were collected pre- and post-dance. Results indicated that tango increased positive affect and reduced salivary cortisol. It was therefore suggested by the investigators that tango may indeed be a viable anti-stress leisure activity. This supports the proposed PA, affective state, and improved mental health link put forth by Hyde and colleagues.[39] Tango was also used in a Latin dance intervention (a weekly 90 min class) for adults with depressive-, anxiety-, or stress-related symptoms.[21] Primary outcomes were determined using the 21-item multidimensional Depression Anxiety Stress Scales questionnaire. It was revealed that both depression and psychological stress decreased in the tango group post-intervention. No changes were observed in a control group. The findings of the two aforementioned studies support the work of Mastura and colleagues[59] and West and colleagues,[60] who also showed that dance involvement imparts beneficial effects on mental health via reduction of both short- and long-term psychological stress. In another study of Latin dance, adults self-reporting depressive symptoms attended a 1 h salsa session once

weekly.[27] The Beck Depression Inventory was used for assessment of depressive symptom severity. Despite this intervention not having a control group, depression levels were shown to improve from before to after engagement in dance. These results support the findings of Chen and Millar,[85] who reported that leisure PA of at least a moderate intensity (which salsa dancing is[26,80]), regardless of type, correlates with improved depressive-related health outcomes in otherwise healthy adults.

2.6. Latin-themed aerobic dance for health promotion

Zumba fitness is a non-partnered form of Latin-themed aerobic dance and is currently practised by an estimated 14 million people in over one hundred fifty countries,[29] yet minimal evidence from well-designed randomised controlled studies[67,74,75] exists to substantiate its purported health-enhancing efficacy. Barene and colleagues[74,75] assessed apparently healthy adults in a two-phase evaluation of Zumba fitness. Two to three 1 h weekly dance sessions were attended over the study period. The participants increased VO_{2max} and decreased BMI and percent body fat (BF) post-intervention. Similarly, Donath and colleagues[67] revealed decreased BMI following a Zumba fitness intervention in apparently healthy women. Two 1 h weekly classes were attended. In contrast, however, the same volume of Zumba fitness sessions resulted in no change in BMI for physically inactive obese women in an intervention, although BP decreased post-dance.[76] It should be noted, however, that this research (similar to the recent work of Krishnan and colleagues[86] and Micallef[87]) was published as a single-arm study without a control group. Additionally, the authors reported that mean attendance in the Zumba fitness classes was only 71% for participants who completed the research. This may explain, at least in part, the unaffected BMI. No improvements were reported for control participants in either the work of Barene and colleagues[74,75] or Donath and colleagues.[67]

To date, no other interventions have made use of Zumba fitness as a modality of PA promotion, although three relevant observational studies were found in a review of the literature. Sternlicht and colleagues[88] evaluated the physiological responses to DVD-based Zumba fitness sessions performed by licensed Zumba fitness instructors; Luettgen and colleagues[89] undertook similar measures during instructor-led Zumba fitness sessions performed by

experienced Zumba fitness participants; and Dyrstad and Hausken[90] assessed the energetic cost of Zumba fitness in university-recruited student athletes. There are, however, some significant limitations that warrant highlighting regarding these recent investigations.

In the DVD-based Zumba fitness study,[88] EE values from female and male participants were analysed together. This may have confounded the results, as EE during Latin dance has been shown to be different between women and men during performance of the same choreography.[77] This is likely due to physiological and anthropometric differences (primarily in terms of BM and composition) between the sexes.[91] Furthermore, it has already been demonstrated that physiological responses in dance instructors and regular class participants during aerobic dance are different,[92] thus, the ability to make inferences to a general population is limited as the participants in this research were all licensed Zumba fitness instructors. Dyrstad and Hausken[90] investigated EE during Zumba fitness using accelerometry and four different prediction equations for processing of the accelerometer output signal. No criterion reference, however, for the measurement of actual EE was used in this study; the validity of the results is therefore clearly limited. Moreover, the prediction equation[93] selected by the authors as the reference against which the other equations were compared has now been shown to be invalid for EE assessment during Latin dance.[77] The EE of Zumba fitness as reported by Luettgen and colleagues[89] was estimated from equations based on heart rate (HR) to oxygen uptake (VO_2) relationships established during treadmill activity. These results, however, are likely to be confounded as dance is kinematically dissimilar to standard ambulatory activities performed on a treadmill. An observed disproportionate relationship between HR and VO_2 during dance was attributed to the higher amount of (mostly overhead) arm involvement when dancing in comparison with jogging.[94] The authors of this research, which was published in 1989, consequently, and others since,[95,96] have argued against the assumption that a strong linear relationship exists between HR and VO_2 during dance as it does in traditional laboratory-based modalities of exercise,[97,98] such as running and cycling.

2.7. HR and VO_2 measures in dance research

Current portable indirect calorimetry systems permit breath-by-breath pulmonary gas exchange data to be collected without the burden of having to be attached to a central unit via cables. This equipment is designed to be as small and convenient to wear as possible and is of good utility for the assessment of activities that may involve turning and spinning actions or have substantial overhead arm movements, such as those characteristically found in dance. However, before this equipment became available researchers evaluated physiological responses to dance primarily via the method of short-range HR radio telemetry. The HR data were then used for VO_2 estimation based on the relationship between HR and VO_2 established during a laboratory-based graded exercise test, usually performed on a treadmill or cycle ergometer.

The HR response during dance was first reported in a study published in 1970, whereby a purpose-built HR telemetry system was used during on stage performance.[99] Measurement of VO_2, however, was not reported in this research. Several years later, Londeree and Ames[98] demonstrated strong relationships between HR and VO_2 during treadmill walking and running in adults of varying cardiorespiratory fitness levels. The strength of the reported regression was ~0.97 with a standard error of the estimate (SEE) of < 6%. Schantz and Astrand[100] were the first investigators to then compare predicted VO_2 from HR recorded during dance with measured values assessed using a modified Douglas bag technique. Unfortunately, differences of up to 15% were observed between predicted and measured values. This is likely explained by the fact that the prediction equations used had been developed from running and cycling, whereas typical movements of dancers are different to those of runners and cyclists. Movement restriction problems were also noted in the Schantz and Astrand study[100] due to limitations of the Douglas bags used. Furthermore, some genres of dance have been characterised as intermittent activities,[96] whereas standard laboratory-based testing protocols for assessment of HR and VO_2 are based on continuous exercise modalities.

By the late 1980s, VO_2 and EE measures during dance continued to be reported via HR and the use of prediction equations,[101] despite further investigations demonstrating the limitations of this method for dance when the relationship between HR and VO_2 is derived using a non-dance-specific

activity.[94] Thomsen and Ballor[95] were the first to suggest that VO_2 prediction equations for dance ought to be developed using dance-specific movements, while Redding and colleagues[96] later posited that individual regressions, as opposed to group-wise regressions, may be more effective (albeit less practical) for the assessment of VO_2, and therefore EE, during performance of dance in environments where the use of portable indirect calorimetry is not feasible.

Over the past decade, investigators of dance in a PA and health promotion context have continued to make use of VO_2 and EE prediction equations developed using non-dance-specific methods. Recent studies involving (non-Latin) aerobic dance,[102] salsa,[26] and Zumba fitness[89] have all reported measures of either VO_2 or EE using this likely confounded technique. Wyon and colleagues,[103] however, were the first to develop and validate a multi-stage incremental dance trial based specifically on movements relevant to contemporary dance. More recently, a similar protocol was developed and validated for ballet.[104] Although both of these studies were conducted for the physiological assessment of trained dancers (i.e., for on stage performance-related purposes), to date, no investigations have resulted in a dance-specific method to physiologically evaluate Latin dance in a PA and health promotion context.

2.8. Accelerometry in dance: primary outcomes of EE, SC, and MVPA

Wearable motion sensing devices commonly used by PA investigators now allow high resolution triaxial data registration with simultaneous HR recording. Although accelerometers have been used in PA research since the early 1980s,[105] this technology has only recently emerged as a potentially viable measurement method in dance research. It is accepted that PA can be validly quantified using accelerometry,[106] and although objective evaluations of dance have been reported using these devices,[72,80,90] dance-specific value calibrations (i.e., conversion of the accelerometer output signal into relevant metrics) for the determination of EE, step count (SC), and the development of cut-points to establish time spent in MVPA have not yet been undertaken.

An intervention using the method of accelerometry demonstrated that Latin dance is effective for increasing weekly EE related to PA[72]; however,

dance intervention research utilising criterion-referenced modality-specific objective data collection methods is non-existent. Moreover, there is uncertainty in whether EE and SC value calibrations developed from walking, running, and lifestyle activities (the three most reported forms of PA utilised in accelerometer value calibration studies) remain accurate when used to evaluate kinematically dissimilar movements,[107,108] yet investigators of dance continue to make use of non-dance-specific methods to characterise the activity. Di Blasio and colleagues[80] reported measures of EE during salsa dance using an accelerometer-based device value calibrated from walking, running, cycling, and resistance training.[109] Engagement in MVPA during salsa, merengue, bachata, and cha-cha-chá was examined by Lee and colleagues also using accelerometry[72]; however, a cut-point system value calibrated from self-paced walking was selected for data processing. No criterion reference measurement or validity testing was undertaken in either of these studies. Additionally, SC during dance has been shown to be invalid when predicted from accelerometer-based devices intended for standard ambulatory activities.[110,111]

There are, clearly, significant limitations in the literature regarding previous investigations of dance that have attempted to make use of motion sensing devices for the objective evaluation of EE, SC, and MVPA. Also, in the broader context of PA and health promotion for the general adult population, to date, no accelerometer-based studies of dance have been published using previously validated activity-specific techniques. As such, several initial issues need to be clarified regarding the gaps in the literature concerning dance research and the use of objective measurement by accelerometry: firstly, it is unclear whether value calibrations created for a single specific activity (i.e., dance) are better than currently available generalised models; secondly, potential differences between accelerometer placement sites on the body have not yet been fully explored within a dance context; and thirdly, it remains uncertain whether the predictive ability of EE, SC, and MVPA during dance can be improved by combining accelerometry with a physiological measure, such as HR recording.

2.9. Thesis aims and objectives

Social dance, as a leisure activity, has the potential to play a role in the engagement of adults in physically active pursuits that are not necessarily

thought of as traditional exercise per se. This is especially important for those individuals not currently meeting PA guidelines and is fully congruent with the current public health message that "some activity is better than none".[112] To that end, the objective of this research was to determine the efficacy of Latin dance as a health-enhancing leisure activity in non-clinical adults. A comprehensive evaluation was undertaken encompassing quantitative assessments of both physiological and psychological measures related to engagement in partnered salsa dance and non-partnered Zumba fitness. The decision to simultaneously evaluate both physiological and psychological responses to dance in the context of PA and psychosocial health promotion was made based on the fact that no previous studies have investigated Latin social dancing in this fashion; therefore, potential relationships between physical and mental health-related outcomes, which may indeed exist in Latin dance and be relevant for a holistic understanding of the activity, remain unexplored. The research undertaken comprised four interrelated dance studies, each with its own specific set of aims and objectives.

In Study 1, research grade motion sensing and HR monitors were used to measure the physiological parameters of salsa dance when performed under laboratory-based conditions. A value calibration process was undertaken to convert the accelerometer output signal into relevant metrics. Different accelerometer placement sites on the body were explored and a comparison was made with an existing value calibration method to determine the difference between generalised and activity-specific techniques for the accelerometer quantification of dance. The principal aim of Study 1 was *to value calibrate, cross-validate, and determine the reliability of a combined triaxial accelerometry and HR telemetry technique for characterising the physiological and PA parameters of Latin dance.*

In Study 2, the monitors selected for use in the aforementioned work were utilised in a naturalistic setting for evaluation of Latin partnered social dance. PB of dance were recorded and state IM was captured immediately post-dance. The principal aim of Study 2 was *to investigate the physiological and perceptual responses to Latin partnered social dance to salsa music when performed as a self-selected activity within an ecologically valid setting.*

In Study 3, participants were recruited to take part in classes of dance; both salsa (partnered and generally attended for the development of dance technique) and Zumba fitness (non-partnered and generally attended for exercise purposes) were evaluated. Acute changes in PWB and PD were investigated and relationships between physiological and psychological measures were explored. The principal aim of Study 3 was *to simultaneously assess the physiological responses and psychological experiences during instructor-led group classes of Latin dance and Latin-themed aerobic dance in a community sample of physically inactive women.*

In Study 4, a two-arm randomised controlled study of Zumba fitness was conducted in a community-recruited cohort of women. The effects of Latin-themed aerobic dance on change in inflammatory biomarkers, cardiovascular risk factors, mood, and HRQoL were investigated. The principal aim of Study 4 was *to determine the health-enhancing efficacy of an 8 wk Zumba fitness intervention on measures of BMI, BF,* VO_{2max}*, BP, cholesterol, CRP, IL-6, WBC, mood, and HRQoL in overweight and physically inactive women.*

3 GENERAL METHODS

3.1. Participants

Recruitment for Studies 1 and 2 was undertaken using advertisements directed to Latin dance schools and related organisations in and around London, UK. This involved primarily: online posting in relevant interest groups using Facebook software, i.e., London Salsa (facebook.com/groups/55412855779); online posting on relevant websites with public message forums, i.e., Salsa Jive (salsajive.co.uk); emailing dance schools directly, i.e., Streetbeat Salsa Dance Company; and liaising with organisations involved in dance-related research, i.e., Dance UK. Recruitment for Studies 3 and 4 was undertaken using poster advertisements placed in the Royal Borough of Kingston and the surrounding communities of London, UK; an example research poster advertisement is presented in full (Appendices). This involved: placement of printed posters in high traffic locations, i.e., on community noticeboards; poster advertising on the campuses of Kingston University; and liaising with organisations involved in PA and health promotion that agreed to assist with poster distribution, i.e., Kingston Council Public Health Team.

The undertaken studies had been approved by the Faculty Ethics Committee at Kingston University and were conducted in accordance with the Declaration of Helsinki of 1964 (2008 amendment). Ethical approval was granted with confirmation number 11123/020 in February 2012. The participants gave their informed consent in writing before commencement of the research and after the experimental procedures, risks, and benefits of participation had been explained; an example information sheet and informed consent form is presented in full (Appendices). For all studies, a PA readiness form for exercise screening was completed to ensure the participants were free from musculoskeletal injury at the time of data collection; this document is presented in full (Appendices). Inclusion criteria and descriptive characteristics

of the participants for Studies 1, 2, 3, and 4 are presented in detail in Chapters 4, 5, 6, and 7, respectively.

3.2. Laboratory procedure

In all studies, the participants visited the laboratory and after 15 min of seated rest, resting HR and BP were measured using an automated monitor (Elite 7300IT, Omron Healthcare Inc, Lake Forest, IL, USA). Readings were obtained in duplicate and mean values were used for data analysis. This monitor uses the oscillometric method for determination of BP and has been validated for use against the European Society of Hypertension International Validation Protocol[113] for BP monitoring. Stature was determined to the nearest 0.1 cm using a stadiometer (213, Seca Ltd, Birmingham, UK). BM and BF to the nearest 0.1 kg and 0.1%, respectively, were assessed using a multifrequency bioelectrical impedance analyser (MC 180MA, Tanita Europe BV, Amsterdam, Netherlands). The MC 180MA is a stand-on device that measures resistance to a small electrical current passed through the body between eight electrodes and converts the impedance into BF using a proprietary algorithm. BF measurements from this analyser have been significantly correlated with measurements taken using the gold standard method of dual energy X-ray absorptiometry.[114] Capillary blood samples were collected in Studies 1 and 2 and venous blood was collected in Study 4; detailed descriptions of the procedures used for blood sampling and analysis are presented in Chapters 4, 5, and 7, respectively.

A graded treadmill exercise test to volitional exhaustion was performed for determination of VO_{2max} and maximal HR (HR_{max}) in Studies 2, 3, and 4. Breath-by-breath pulmonary gas exchange data were collected using an indirect calorimeter (Oxycon Pro, Viasys Healthcare GmbH, Hoechberg, Germany). The Oxycon Pro measures pulmonary ventilation (VE) using a turbine unit with an optoelectrical reader, which is connected to the participant's facemask (Series 7450V2, Hans Rudolph Inc, Shawnee, KS, USA). Expired air is sampled via a capillary line and VO_2 and carbon dioxide output (VCO_2) concentrations are measured by paramagnetic and infrared sensors, respectively. Room air, delay, turbine, and gas calibrations were conducted using a 3 L syringe (Series 5530, Hans Rudolph Inc, Shawnee, KS, USA) and gases of known concentration prior to commencement of each test

according to the manufacturer's instructions. This device has been validated for use against the gold standard Douglas bag method.[115] HR was measured continuously using a short-range radio telemetry system (RS400, Polar Electro Oy, Kempele, Finland) consisting of a chest strap transmitter and wrist watch receiver. The RS400 has been validated for use against the gold standard method of electrocardiography.[116] A description of the treadmill test and criteria used for establishment of VO_{2max} is presented in detail in Chapter 5. In Study 1, a portable indirect calorimeter ($K4b^2$, Cosmed Srl, Rome, Italy) was used during performance of the laboratory-based dance trial. The $K4b^2$ measures pulmonary gas exchange variables on a breath-by-breath basis and transmits the data to a receiver unit connected to a computer for real-time monitoring. The body-worn system has a mass of 1.1 kg and is secured to the upper back and chest using a harness provided by the manufacturer (Figure 3.1). Similar to the Oxycon Pro, a reader determines VE from expired air using a turbine, and concentrations of VO_2 and VCO_2 are sampled and measured via onboard sensors. A detailed description of how the $K4b^2$ was used during the dance trial is presented in Chapter 4. This device, like the Oxycon Pro, has

Figure 3.1. A participant performing the laboratory-based dance trial to the choreography video in Study 1 using the $K4b^2$ portable indirect calorimeter (photographic permission given by the participant for use in this thesis).

been validated for use against the gold standard Douglas bag method.[117] Further laboratory procedures and descriptions of the dance sessions for Studies 1, 2, 3, and 4 are presented in detail in Chapters 4, 5, 6, and 7, respectively.

3.3. Instruments

In Study 1, triaxial accelerometers (GT3X+ 2.5, ActiGraph LLC, Pensacola, FL, USA) were worn on the right wrist (dorsal surface between the radial and ulnar styloid processes), right hip (posterior to the anterior superior iliac spine), and right ankle (superior to the lateral malleolus). The wrist- and ankle-mounted devices were secured using elastic bandage, while the hip-mounted device was attached to an elastic belt supplied by the manufacturer. For the dance sessions in Studies 2, 3, and 4, a single triaxial accelerometer (wGT3X+ 2.0, ActiGraph LLC, Pensacola, FL, USA) was worn on the right wrist. All devices were initialised using the manufacturer's software (Actilife 6.2, ActiGraph LLC, Pensacola, FL, USA) for data recording on the vertical, anteroposterior, and mediolateral axes at a sampling frequency of 100 Hz. The dynamic range of the devices is ± 6 *g*. The manufacturer's accompanying chest strap monitor, worn at the level of the xiphoid process of the sternum, was utilised for recording of HR. The monitor, which has a mass of 40 g, permits measurement of HR and telemetry of data via the ANT+ protocol to the accelerometer for recording. Downloading of the HR and vector magnitude (VM) acceleration data was undertaken using the manufacturer's software with 1 s epochs selected and the low frequency extension enabled. In Study 4, the wrist-worn accelerometer (without HR recording) was also used for collection of habitual movement data during all waking hours of the first seven consecutive days of the study period, with exceptions made only for water-based activities (i.e., bathing). The VM acceleration data were downloaded in a similar fashion to that described for dance, except 60 s epochs were selected. The accelerometer allows continuous recording of both body acceleration and HR, and is lightweight (19 g), small (4.6 x 3.3 x 1.5 cm), and unobtrusive. Furthermore, the equipment neither restricts body movement nor impedes the ability to dance normally; these assessments were made during pilot testing for Study 1, which took place in March 2012.

In Study 2, state IM for salsa dance was assessed using the IMI.[118] This questionnaire taps four dimensions of IM and is rated on a Likert-type scale ranging from one (strongly disagree) to seven (strongly agree). The questionnaire was originally validated by McAuley and colleagues[118] using one hundred sixteen physically active women and men with a mean age of 21 yr. Cronbach coefficient alphas[119] of 0.80, 0.87, 0.84, and 0.68 were reported for the dimensions of interest-enjoyment, perceived competence, effort-importance, and tension-pressure, respectively. The 16-item version of the questionnaire was administered. Completion time for the IMI in Study 2 was ~5 min. The Exercise Benefits/Barriers Scale (EBBS)[120] was also used in Study 2 for assessment of the PB of salsa dance. The 43-item questionnaire uses a Likert-type scoring system ranging from one (strongly disagree) to four (strongly agree). Only the benefit items of the questionnaire were scored; barrier items were ignored. PB are comprised of the following five dimensions: life enhancement; physical performance; psychological outlook; social interaction; and preventative health. Original validation of the questionnaire was performed by Sechrist and colleagues[120] using six hundred fifty community-recruited adults of both sexes. The mean age was 39 yr and the sample comprised both physically active and non-exercising individuals. A Cronbach coefficient alpha of 0.95 was reported for the benefits component of the questionnaire. Completion time for the EBBS in Study 2 was ~10 min.

In Study 3, acute change in PWB and PD was evaluated using the SEES[65] consequent to participation in classes of salsa dance and Zumba fitness. The questionnaire is rated on a Likert-type scale ranging from one (not at all) to seven (very much so) with a midpoint anchor at four (moderately). McAuley and Courneya[121] originally validated the 12-item questionnaire in a series of three interrelated studies. The first comprised four hundred twelve physically active women and men with a mean age of 21 yr; the second, one hundred physically active community-recruited individuals of both sexes and with a mean age of 54 yr; and the third, fifty-one non-exercising women and men recruited from the community with a mean age of 55 yr. Cronbach coefficient alphas of 0.86 and 0.85 were reported for the dimensions of PWB and PD, respectively. Items pertaining to fatigue were not scored. Completion time for the SEES in Study 3 was ~2 min.

In Study 4, change in mood and HRQoL following an 8 wk Zumba fitness intervention was assessed. The six dimension Profile of Mood States 2nd Edition Short Form for Adults (POMS-2)[122] was used for evaluation of mood. The 35-item questionnaire is scored on a Likert-type scale ranging from zero (not at all) to four (extremely) and has been reported to have Cronbach coefficient alphas of 0.86, 0.84, 0.88, 0.87, 0.84, and 0.83 for the dimensions of anger-hostility, confusion-bewilderment, depression-dejection, fatigue-inertia, tension-anxiety, and vigour-activity, respectively. Original validation was performed by Heuchert and McNair[122] using 1000 apparently healthy women and men and two hundred fifteen clinical adults of both sexes who were experiencing anxiety- or depressive-related symptoms. Mean age and PA data were not reported in the study. Completion time for the POMS-2 in Study 4 was ~5 min. HRQoL was measured using the RAND 36-Item Health Survey 1.0 (SF-36).[123] Hays and colleagues[123] originally validated the 36-item questionnaire using 2471 clinical adults of both sexes (individuals with hypertension, type two diabetes, cardiovascular disease, or depression). The mean age of the sample was 56 yr; PA data were not reported. Cronbach coefficient alphas of 0.93, 0.84, 0.78, 0.78, 0.86, 0.85, 0.83, and 0.90 were reported for the dimensions of physical functioning, role limitations due to physical health, pain, general health, energy/fatigue, social functioning, role limitations due to emotional problems, and emotional well-being, respectively. Completion time for the SF-36 in Study 4 was ~10 min. Further details regarding questionnaire administration during Studies 2, 3, and 4 are presented in Chapters 5, 6, and 7, respectively. The IMI, EBBS, SEES, POMS-2, and SF-36 are presented in full (Appendices).

In the context of psychometric properties, Cronbach coefficient alpha is a measure of the internal consistency of a psychological questionnaire, expressed as a value between 0.00 and 1.00. Internal consistency describes the extent to which the questionnaire items measure the same construct. Cronbach coefficient alpha is affected by the overall number of items and item interrelatedness.[119] Generally accepted values range from 0.70 to 0.95.[124] Squaring Cronbach coefficient alpha and subtracting the result from 1.00 produces a measurement error index, i.e., if a questionnaire's Cronbach coefficient alpha is 0.95, the measurement error index (or expected random

variance) would be 0.10. All of the questionnaires selected for use in the current research were considered to be adequately internally consistent.

4 STUDY 1

4.1. Title

Combined triaxial accelerometry and heart rate telemetry for the physiological characterisation of Latin dance in non-professional adults.

4.2. Introduction

Technological advancements in wearable motion sensing devices commonly used in human movement research now permit high resolution data registration across multiple axes while simultaneously recording HR. Accelerometer-based activity monitors have been used by PA investigators since the 1980s[105]; however, this technology has only recently emerged as a viable measurement method in the dance and exercise sciences. It is accepted that PA and exercise can be validly measured using the method of accelerometry, and although objective assessments of Latin social dance have been reported,[26,80] dance-specific accelerometer value calibrations for the determination of EE, SC, and the development of PA intensity cut-points have not yet been conducted. The process of value calibration involves conversion of the accelerometer output signal into a useable metric, as described in detail elsewhere,[125] and plays an integral role in the quantification of movement by accelerometry.

An intervention published in 2011 demonstrated that Latin dance is effective for increasing weekly EE related to PA[72]; however, dance intervention research utilising criterion-referenced activity-specific objective data collection methods are non-existent. Moreover, it is uncertain whether accelerometer EE and SC prediction models developed from walking, running, and lifestyle activities remain accurate when used to evaluate kinematically dissimilar movements,[107,108] such as dance. Estimation of SC during ballroom dance, for example, has been shown to be invalid when predicted from accelerometer-based devices intended for standard ambulatory activity.[110] SC is a metric commonly used by PA researchers as an indicator of activity

intensity[126] and can be easily interpreted by both dance and exercise scientists, thus facilitating knowledge translation. In terms of PA and health promotion, accuracy in SC prediction is imperative if activities such as Latin dance are to be described thoroughly.

The most commonly employed method to quantify work intensity during dance performance is the measurement of HR. This physiological parameter is associated with EE[127]; nevertheless, it has been postulated that simultaneous motion sensing and HR recording may prove to be a more precise predictor of EE than either technique used independently.[106] Furthermore, as Latin dance involves both the upper and lower body, it is unclear at the present time where the soundest anatomical site for accelerometer placement is. Also in need of clarification, is whether the known physiological and anthropometric differences between women and men[91] (primarily in terms of BM and composition) affect EE during Latin dance, and consequently, whether the generation of sex-specific accelerometer prediction models is necessary. As such, the purpose of this study was to value calibrate, cross-validate, and determine the reliability of a combined triaxial accelerometry and HR telemetry technique for characterising the physiological and PA parameters of Latin dance.

4.3. Methods

Recruitment for this research was undertaken using advertisements directed to Latin dance schools based in London, UK. Twenty-two non-professional adult Latin dancers (fourteen women and eight men, aged 24 to 56 yr) volunteered to participate in the study. The dancers were social performers who engaged in dance for recreational purposes only. Ethical approval was granted by the Faculty Ethics Committee at Kingston University, and the study was conducted in accordance with the Declaration of Helsinki. Descriptive characteristics of the sample are presented (Table 4.1). The dancers gave their informed consent in writing before the commencement of the study and after the experimental procedures, risks, and benefits of participation had been explained. Instructions were given to arrive at the laboratory euhydrated, at least 2 h postprandial, and to avoid strenuous PA in the 24 h preceding testing. A PA readiness form[128] for exercise screening was completed and all dancers were found to be free

Table 4.1. Descriptive characteristics of non-professional Latin dancers from London, UK.

	Total	Women (n = 14)	Men (n = 8)
Age (yr)	36 ± 10	36 ± 12	35 ± 5
BM (kg)	66.5 ± 10.9 *	62.5 ± 9.9	73.4 ± 9.2
BF (%)	21.9 ± 7.1 **	25.5 ± 5.2	15.6 ± 5.6
BMI (kg/m^2)	23.2 ± 2.8	22.9 ± 3.1	23.6 ± 2.4
Latin dance experience (yr)	4 ± 4	4 ± 4	5 ± 4
Latin dance frequency (h/wk)	6 ± 4	6 ± 5	7 ± 3

Data are presented as mean ± standard deviation; BF = percent body fat; BM = body mass; BMI = body mass index; * and ** indicate significant differences between sexes at $p < 0.01$ and $p < 0.001$, respectively.

from musculoskeletal injury at the time of laboratory testing. As the required choreography for the study was suitable for intermediate to advanced Latin dancers, it was stated in the inclusion criteria that this research would not be appropriate for novices as the complexity of the performance would likely be too difficult.

The dancers visited the laboratory on two occasions over a 1 wk period to perform an individual (i.e., non-partnered) multi-stage Latin dance trial. The dance trials were performed at the same time of day (± 1 h) under environmentally controlled conditions. After arrival on the first day and following 15 min of seated rest, resting HR was measured using an automated monitor (Elite 7300IT, Omron Healthcare Inc, Lake Forest, IL, USA). Stature was determined with a stadiometer (213, Seca Ltd, Birmingham, UK), and BM and BF were assessed using a multifrequency bioelectrical impedance analyser (MC 180MA, Tanita Europe BV, Amsterdam, Netherlands). Latin dance experience and frequency were self-reported.

The dancers were then familiarised with both the laboratory equipment and protocol of the dance trial. The dance trial involved completing three 5 min stages of an Afro-Cuban salsa choreography, with each stage increasing in both tempo and complexity of the steps performed, while following a video displayed on a projection screen. A 1 min passive rest period separated the stages. The video utilised in this study was choreographed by a dance company from London, UK and was filmed for the purposes of this research project. The tempi of the songs selected were 172, 192, and 212 beat/min (4/4 time

signature), and were chosen as they represent slow, medium, and fast salsa rhythms commonly found when dancing socially. The choreography video included a 5 min warm-up of salsa-specific dynamic stretches and dance performed at 202 beat/min (4/4 time signature), which preceded the first stage of the dance trial. The choreography required execution of commonly taught elements of Afro-Cuban salsa and included variations of: the basic step in both forward/backward and left/right directions; half, full, and double turns; crossover steps; Cuban cha-cha-chá and mambo, Afro rumba, and contratiempo son steps; and orisha/santo movements specific to Afro-Cuban dance.

Triaxial accelerometers (GT3X+ 2.5, ActiGraph LLC, Pensacola, FL, USA) were worn by the dancers (a complete description of which is presented in Section 3.3). HR was measured using a short-range radio telemetry system (RS400, Polar Electro Oy, Kempele, Finland) consisting of a chest strap transmitter and wrist watch receiver. Breath-by-breath pulmonary gas exchange data were collected using a portable indirect calorimeter ($K4b^2$, Cosmed Srl, Rome, Italy) secured to the upper back and chest by a harness. Gas volume and concentration signals were sampled via a capillary line connected to a turbine volume transducer on the dancer's facemask (Series 7450V2, Hans Rudolph Inc, Shawnee, KS, USA). Calorimeter room air, delay, turbine, and gas calibrations were conducted using a 3 L syringe (Series 5530, Hans Rudolph Inc, Shawnee, KS, USA) and gases of known concentration prior to commencement of each dance trial. SC was observed and tallied by lower body video recording. Immediately following each stage of the dance trial on the first laboratory visit, a 20 μL capillary blood sample was collected from the fingertip for assessment of lactate using an automated analyser (Biosen, EFK Diagnostic GmbH, Barleben, Germany) and rating of perceived exertion (RPE) was determined using the Borg 6 to 20 scale[129]; this document is presented in full (Appendices).

Calculations of EE, SC, HR, heart rate reserve (HRR), VE, VO_2, VCO_2, and vector magnitude acceleration of the wrist (WRI), hip (HIP), and ankle (ANK) were undertaken using the mean of the data collected during the final 3 min of each stage of the dance trials. EE was computed via the Weir equation,[130] HRR was formulated using previously described methods,[127] and

metabolic equivalents (MET) to establish PA intensity cut-points were determined by dividing VO_2 by 3.5 mL/kg/min.

All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS 19.0, IBM Corp, Armonk, NY, USA). Independent *t*-tests were used to evaluate the descriptive characteristics and ascertain differences between female and male dancers. Accelerometer cut-points for sedentary, light, moderate, and vigorous intensity PA were established via bivariate regression. Forced entry multiple regression was used to value calibrate the GT3X+ for sex-specific prediction of EE and SC. Cross-validation was undertaken using a delete-one jackknife approach with dependent *t*-tests examining differences between predicted and measured values. Additionally, Bland-Altman plots[131] were utilised for analysis of systematic bias, calculation of root mean square error, and to establish the 95% limits of agreement between methods. Reliability of measures between trial days was determined using dependent *t*-tests and repeated measures analysis of variance (RM-ANOVA) was used to evaluate changes between stages of the dance trial. A WRI:HIP:ANK ratio of upper to lower body movements was arithmetically calculated and EE estimations from a validated treadmill-based prediction model[93] were compared to measured values via dependent *t*-test analysis. Alpha was set at 0.05 and Bonferroni corrections were made for pairwise comparisons. Measures of centrality and spread are presented as mean ± standard deviation with 95% confidence intervals (CI) reported where appropriate. Non-normally distributed data were assessed using non-parametric equivalents of the above treatments (i.e., Mann-Whitney and Wilcoxon signed-rank tests and Friedman's analysis of variance (ANOVA)).

4.4. Results

Comparison with existing EE model and assessment of upper to lower body movements

When Latin dance EE was predicted using HIP and the validated Sasaki and colleagues[93] prediction model, values were significantly lower ($p < 0.001$) than measured EE by an average of 1.60 [95% CI 1.41 – 1.79] kcal/kg/h, or 26 [95% CI 23 – 29] %. A WRI:HIP:ANK ratio of 3.19:1.00:2.39 indicated a 34% difference between upper and lower body movements.

Derived models for the prediction of EE

The predictive ability of the derived sex-specific EE models using HR combined with ANK and HR combined with HIP was $R^2 = 0.43$, SEE = 0.74, $p < 0.001$ and $R^2 = 0.52$, SEE = 0.68, $p < 0.001$, respectively. When sex-specific models for EE were developed from WRI alone or HR alone, the predictive ability was $R^2 = 0.71$, SEE = 0.52, $p < 0.001$ and $R^2 = 0.27$, SEE = 0.83, $p < 0.001$, respectively. Latin dance experience did not make a significant contribution ($\beta = 0.04$, $p = 0.48$) to the ability to predict EE when entered into the final model.

Value calibration and cross-validation of final EE and SC models

The final model for EE prediction during Latin dance was value calibrated as EE (kcal/kg/h) = 1.363757 + (0.010282 x WRI) + (0.017040 x HR) + (0.545168 x SEX), where $R^2 = 0.80$, SEE = 0.44, and $p < 0.001$. Additionally, a SC prediction model was value calibrated as SC (step/min) = 97.614892 + (0.072519 x WRI) + (0.051282 x HR) + (3.589022 x SEX), where $R^2 = 0.74$, SEE = 3, and $p < 0.001$. For the above equations, WRI = vector magnitude acceleration of the wrist in count/s, HR = heart rate in beat/min, and SEX = 0 for women or 1 for men. Cross-validation of the EE model revealed no difference ($p = 0.80$) between predicted and measured values. Systematic bias, root mean square error, and the 95% limits of agreement (Figure 4.1) were –0.02, 0.49, and –0.98 to 0.95 kcal/kg/h, respectively. The SC model was also cross-validated, and again no difference ($p = 0.38$) between predicted and measured values was found. Systematic bias, root mean square error, and the 95% limits of agreement for SC (Figure 4.2) were 0, 3, and –7 to 7 step/min, respectively. Although the wrist accelerometer site was deemed to be the strongest for sex-specific prediction of EE, PA intensity cut-points were established for all three accelerometer locations (Table 4.2).

Reliability and results of the multi-stage Latin dance trial

The reliability analysis indicated all parameters measured during the Latin dance trial were no different between trial days (Table 4.3). A significant main effect ($p < 0.001$) of song tempo was revealed for EE, SC, HRR, and RPE; however, song tempo had no effect ($p = 0.38$) on lactate, which had an average value of 1.35 [95% CI 1.23 – 1.48] mmol/L. Post hoc tests indicated

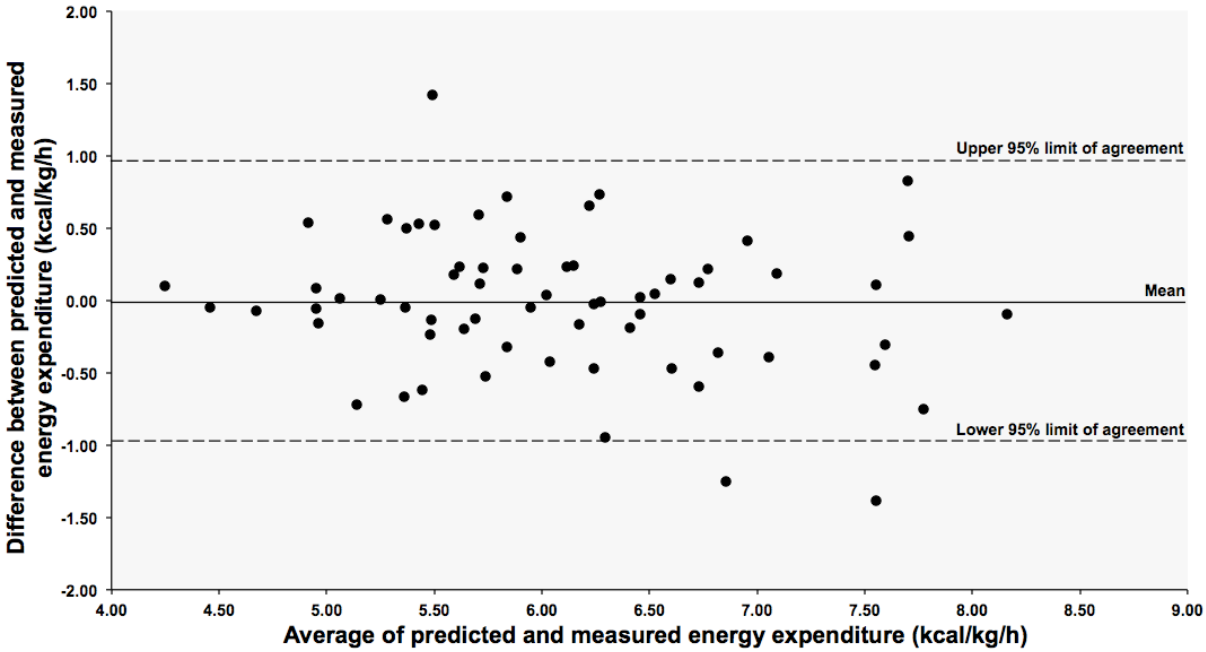

Figure 4.1. Bland-Altman plot[131] assessing agreement between predicted and measured energy expenditure during Latin dance (*N* = 22).

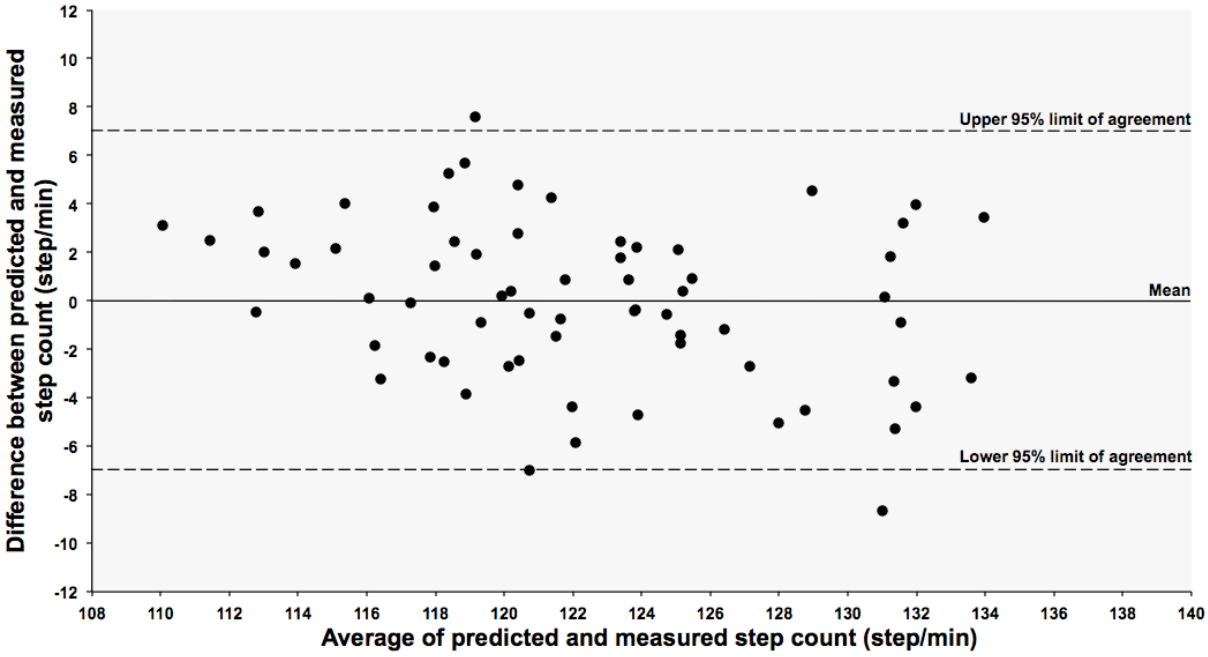

Figure 4.2. Bland-Altman plot[131] assessing agreement between predicted and measured step count during Latin dance (*N* = 22).

Table 4.2. Latin dance-specific cut-points for the ActiGraph GT3X+ triaxial accelerometer (*N* = 22).

		VM acceleration (count/s)		
PA intensity	MET	Wrist	Hip	Ankle
Sedentary	≤ 1.49	≤ 74	≤ 36	≤ 93
Light	1.50 – 2.99	75 – 128	37 – 49	94 – 121
Moderate	3.00 – 5.99	129 – 237	50 – 74	122 – 177
Vigorous	≥ 6.00	≥ 238	≥ 75	≥ 178

MET = metabolic equivalents; PA = physical activity; VM = vector magnitude.

Table 4.3. Reliability of combined triaxial accelerometry and HR telemetry during Latin dance (*N* = 22).

	Trial 1	Trial 2	*p*
EE (kcal/kg/h)	6.16 ± 1.02	6.04 ± 1.16	0.18
SC (step/min)	122 ± 7	123 ± 7	0.07
HR (beat/min)	123 ± 17	124 ± 17	0.70
VE (L/min)	43.21 ± 10.44	43.78 ± 12.06	0.68
VO_2 (mL/kg/min)	20.9 ± 3.5	20.8 ± 4.3	0.35
VCO_2 (L/min)	1.20 ± 0.29	1.20 ± 0.37	0.75
WRI (count/s)	233 ± 74	242 ± 76	0.70
HIP (count/s)	73 ± 15	75 ± 16	0.32
ANK (count/s)	177 ± 44	176 ± 32	0.19

Data are presented as mean ± standard deviation; ANK = vector magnitude acceleration of the ankle; EE = energy expenditure; HIP = vector magnitude acceleration of the hip; HR = heart rate; SC = step count; VCO_2 = carbon dioxide output; VE = pulmonary ventilation; VO_2 = oxygen uptake; WRI = vector magnitude acceleration of the wrist.

EE during stage 1 (5.44 [95% CI 5.14 – 5.73] kcal/kg/h) was significantly lower ($p < 0.001$) than stages 2 and 3 (6.23 [95% CI 5.85 – 6.60] and 6.59 [95% CI 6.17 – 7.02] kcal/kg/h, respectively), with the difference between stages 2 and 3 also reaching significance ($p < 0.01$). SC during stage 1 (119 [95% CI 116 – 121] step/min) was significantly lower ($p < 0.001$) than that of stages 2 and 3 (124 [95% CI 121 – 126] and 125 [95% CI 122 – 128] step/min, respectively). No change ($p = 0.28$) between the latter two stages was observed. Measures of HRR significantly increased ($p < 0.001$) across stages of the dance trial (37.4 [95% CI 33.5 – 41.3], 46.9 [95% CI 42.8 – 51.0], and 53.3 [95% CI 48.9 – 57.8] % for stages 1, 2, and 3, respectively). Changes in subjective effort also significantly increased ($p < 0.001$) across all stages (10

[95% CI 10 – 11], 12 [95% CI 12 – 13], and 14 [95% CI 13 – 15] RPE for stages 1, 2, and 3, respectively).

4.5. Discussion

The purpose of this study was to investigate the physiological and PA parameters of Latin dance and to conduct a HR and accelerometry-based activity-specific value calibration, cross-validity, and reliability analysis. The principal findings were that, despite interindividual variability, i) Latin dance to salsa music elicits physiological responses representative of MVPA when performed by intermediate and advanced adult social dancers, and that ii) a wrist-worn triaxial accelerometer with simultaneous HR measurement constitutes a valid and reliable technique for the prediction of EE and SC during Latin dance with a large[132] and statistically significant proportion of the shared variance in outcome accounted for by using WRI, HR, and sex as regressors.

As evidenced by the WRI:HIP:ANK ratio, performance of Latin dance requires a substantial degree of upper body involvement. The best anatomical site for accelerometer placement during this particular genre of dance was found to be at the wrist. Interestingly, it was noted that the predictive ability of the other derived EE models decreased with placement sites increasingly distal from the wrist. Afro-Cuban orisha/santo dance typically involves considerable polyrhythmic body movements,[24] especially those generated from the upper torso and arms. Examples of these dance elements commonly integrated into Afro-Cuban salsa and involving actions of the upper body include: the orisha of ogún, who is characterised in dance by the swinging of his machete from overhead; and changó, the orisha of thunder and lightning, whose dance involves hurling bolts of lightning also from overhead.

A variety of (non-dance-related) lifestyle and treadmill-based activities were analysed by Lyden and colleagues,[133] who compared predicted and measured EE using three different kinds of accelerometers and eleven different prediction models. The authors suggested that, on the whole, hip-mounted devices cannot be used to accurately assess EE when tasks involve a relatively large amount of upper body movement. The present study supports this notion[134] as cross-validation of our dance-specific model was successful, whereas a significant underestimation resulted when attempting to predict EE

using a validated model[93] value calibrated from walking and running. The differences between upper and lower body activities in terms of VO_2, and therefore EE, are likely related to the smaller muscle mass utilised during tasks that require predominantly upper body movement. It is known that upper body work is less economical and elicits a higher HR for any given VO_2 when compared to lower or combined upper and lower body tasks.[135]

The sex-specific prediction of EE from WRI improved when HR was added to the model. The findings of the present study demonstrate that when taking part in this particular genre of dance, combined motion sensing and HR measurement more accurately describes the energy cost when compared to either technique used alone. Similarly, Crouter and colleagues[136] presented satisfactory predictions of EE when using simultaneous accelerometry and HR recording. In the same study, when EE was predicted from just the accelerometer data, a significant underestimation was present in all 18 activities investigated with the exception of lying down, computer work, and slow walking. The advantage of combined accelerometry with HR has also been reported by others.[137,138]

In an elegantly designed study that combined HR measurement with simultaneous motion sensing, multi-location accelerometry was used and individualised VO_2 to HR relationships were established for both upper and lower body work. An accelerometer-derived ratio was calculated to determine the relative degree of arm and leg contribution to a range of (non-dance-related) activities. The authors, Strath and colleagues,[139] demonstrated that simultaneous accelerometry and HR was a more robust predictor of EE than either technique used independently. Moreover, the shared variance in outcome from the combined method was similar to that of the present investigation (R^2 = 0.81 versus R^2 = 0.80) when sex was generalised; however, when sex-specific models were utilised for the prediction of EE, the shared variance improved (R^2 = 0.89) for women but worsened (R^2 = 0.71) for men. A comparison of predicted and measured EE yielded a systematic bias of 0.10 MET, a result greater than that found in the present investigation (–0.02 kcal/kg/h; where 1 MET = 1 kcal/kg/h). The 95% limits of agreement were also wider in the Strath and colleagues[139] study than those reported in the present research (> ± 1.00 MET versus < ± 1.00 kcal/kg/h), which took sex into

account for the prediction of EE. It is likely that these differences are, at least in part, due to the present study having assessed the energy cost of only a single activity, dance, whereas the research undertaken by Strath and colleagues[139] evaluated EE during 14 different activities.

In recent years, several research projects involving Latin dance have been undertaken in the context of PA and health promotion.[26,72,80] The adult social dancers assessed in this study displayed similar anthropometric characteristics as the dancers examined by Emerenziani and colleagues,[26] where, as expected, males were heavier and leaner than their female counterparts. HRR and EE values somewhat comparable to those measured in the present investigation have been reported by both Di Blasio and colleagues[80] and Emerenziani and colleagues[26] during performance of Latin dance. While these studies shed some light on the physiological demand and potential health benefits of engagement, they were not conducted using objective measurement techniques specifically designed for dance. Lee and colleagues[72] calculated PA volume and intensity during four styles of Latin dance using the relationship between accelerometer data and self-paced walking; Di Blasio and colleagues[80] evaluated Caribbean dance lessons using an accelerometer-based device value calibrated from the activity classes of walking, running, cycling, and resistance training[109]; while Emerenziani and colleagues[26] investigated salsa dance using HR measurement and conversion formulae based on a bench stepping task to estimate energy cost. Furthermore, none of the aforementioned studies analysed the effect of song tempo (which can vary greatly within salsa music) on any of the measured responses.

The authors acknowledge certain limitations of the present study, most notably the fact that the dance performance was non-partnered and took place in a laboratory setting. In order to value calibrate an accelerometer for this particular activity, we felt it was necessary to have the control of a laboratory environment and the dance trial undertaken individually, even if it meant a certain degree of loss of ecological validity. An acknowledged limitation of accelerometry research in general is when value calibrations and PA intensity cut-points are generated from single prediction models intended to cover a wide selection of activities across a broad range of PA intensities.[125] Hence, inevitably, a loss of accuracy in predictive power might occur. The present

investigation generated prediction models for only one activity, Latin dance, and therefore the aforementioned weakness of the accelerometry method we would argue, in this instance, is not applicable. Moreover, the reported data indicate low bias and error along with satisfactory limits of agreement, results that we interpret as being acceptable for the prediction of EE and SC at the individual level. The presented models and cut-points, therefore, can be utilised with confidence in future Latin dance research projects.

Through the use of combined triaxial accelerometry and HR telemetry, we provide in this study the first criterion-referenced activity-specific objective measurement method to quantify the physiological and PA parameters of Afro-Cuban salsa. By using the presented equations, an ActiGraph accelerometer worn on the wrist with accompanying HR monitor can provide, with reasonable accuracy and precision, estimates of both caloric cost and steps taken when Latin dancing to salsa music. The significance of the work described here in terms of its contribution to dance research, the authors feel, is threefold. Firstly, a dance-specific measurement method that can objectively assess EE during dance rehearsals or performances using unobtrusive equipment is novel. The ActiGraph is the most validated[140] commercially available accelerometer used in PA research today, and the value calibration process undertaken in the present study could potentially be replicated with any dance genre. Thus, future establishment of accelerometer prediction models that are specific not only to genre of dance (i.e., contemporary or ballet) but also to age of dancer (i.e., adolescent or adult) is possible. Secondly, the utility of combining motion sensing technology with a physiological measure such as HR should not be underestimated by dance researchers, as prediction of VO_2 (and therefore EE) solely from HR recording, although considered appropriate for kinematically continuous activities measured in the steady-state, has been demonstrated to be unacceptable for non-steady-state intermittently performed genres of dance.[96] Thirdly, it would seem feasible to ask dancers to wear an accelerometer on the wrist in conjunction with a chest strap HR transmitter not only for PA and health promotion research purposes, but also to objectively measure workload (i.e., EE, HR response, or VM acceleration) during dance rehearsals or performances while simultaneously being able to track changes over time.

5 STUDY 2

5.1. Title

Physiological and perceptual responses to Latin partnered social dance.

5.2. Introduction

Despite recognition that PA enhances HRQoL[69] and serves as a protective agent against the overall burden of disease,[12] almost half of all adults in high-income countries remain insufficiently physically active.[1] The benefits of regular PA are firmly established in terms of a reduced risk for the major non-communicable diseases currently threatening global health.[3] Additionally, and having also received extensive attention in the literature, PA is considered able to improve mental health and psychological well-being.[34,141] Exercise has been shown to be therapeutically beneficial for both anxiety and depression,[142] and positive correlations exist between PA and self-esteem and physical self-perceptions.[143]

Dance, a creative leisure pursuit when performed frequently enough to accrue a volume that meets the recommended health maintenance guidelines of at least 150 min of moderate intensity PA weekly,[12] could prove to be an efficacious activity for community-wide recommendation.[31] Latin dance to salsa music has been investigated for its potential to positively affect both physical[26,80] and psychosocial health.[27] Recently, we undertook an assessment of Latin dance using the objective measurement method of combined accelerometry and HR telemetry.[77] Although the study was laboratory-based, a quantification of the characteristics of Afro-Cuban salsa was established. However, as this dance genre is generally performed in a social context (i.e., with partners and in established salsa venues), additional investigation is warranted as only one previous study[26] has attempted to evaluate the physiological demand of Latin partnered social dance within an ecologically valid setting. The aforementioned research estimated energetic cost based on

the relationship between HR and VO_2 established during a non-dance-specific task. HR recording and the use of non-dance-specific value calibration procedures have now been shown to be techniques that are less accurate for the determination of EE in this particular dance genre when compared to the activity-specific method of motion sensing with HR recording.[77]

The measurement of stepping cadence during Latin partnered social dance has not previously been attempted, despite SC being a frequently used metric in the study of PA engagement.[144] The strengths and limitations of objectively measuring SC during ambulatory bipedal locomotor activities, including dance, were recently reviewed by Tudor-Locke and Rowe.[126] A measure of SC during dance would serve not only as an adjunct indicator of PA volume and intensity, but may also be of utility for dance-oriented health promotion strategies. Although certain gait parameters of dance would not necessarily be expected to match those observed when walking or running,[126] the SC metric in a dance context is still meaningful for a comprehensive evaluation of the activity. Furthermore, we have previously demonstrated under laboratory conditions the validity and reliability of SC measurement during performance of Latin dance.[77]

From the self-determination perspective,[7] the fulfillment of competence, autonomy, and relatedness needs have been theorised to contribute to IM for PA and its adherence. It is known that PA adherence is increased under enjoyable and socially supportive environments,[6] and as such, it could be argued that Latin dance is likely a holistic activity that has the potential to foster both physical and mental health. At the present time, however, the IM of non-professional Latin dancers has not been investigated in a social setting. Pender's model of health promotion[145] identified factors that affect certain health-related behaviours, such as engagement in PA and exercise. The PB of these behaviours are determinants within the model, and thus, an assessment of these measures in the context of Latin partnered social dance may shed some light on why individuals perform this activity during their leisure time. Furthermore, to inform the design of PA interventions utilising Latin dance, it is necessary, firstly, to understand the extent to which non-professional Latin dancers are driven by the physical and psychosocial aspects of the activity.

Currently, the PB of the social engagement of this particular dance genre have not been measured.

The purpose of this study was therefore to investigate the physiological and perceptual responses to Latin partnered social dance to salsa music when performed as a self-selected activity within an ecologically valid setting. We sought to examine, using an observational research design and a previously validated dance-specific technique,[77] sex differences in measures of EE, SC, PA volume, and intensity of Latin partnered social dance, and determine what fraction of the total time was spent engaged in dance. Furthermore, to present a holistic understanding of this particular dance genre, the underlying dimensions of state IM were measured and the PB of dance were determined.

5.3. Methods

Recruitment was undertaken using advertisements directed to Latin dance schools based in London, UK. Eighteen non-professional Latin dancers (eleven women and seven men, aged 27 to 57 yr) volunteered to participate in this study, which had been approved by the Faculty Ethics Committee at Kingston University and was conducted in accordance with the Declaration of Helsinki. Descriptive characteristics are presented (Table 5.1). The dancers gave their informed consent in writing before the commencement of the study and after the experimental procedures, risks, and benefits of participation had been explained. A PA readiness form[128] was completed. Inclusion criteria stated that the dancers must have attended Latin social dance events in established salsa venues in London, UK for at least 2 h/wk in the three months preceding the research period, be of a novice to advanced level of Latin dance and a recreational performer only, and be free from musculoskeletal injury at the time of laboratory testing and data collection.

The dancers visited the laboratory to perform a graded exercise test for determination of VO_{2max} and HR_{max}. VO_{2max} was used for descriptive characterisation of the dancers while HR_{max} was necessary to formulate exercise intensity expressed as HRR during dance. Instructions were given to arrive euhydrated, at least 2 h postprandial, and to avoid strenuous PA in the 24 h preceding testing. Following 15 min of seated rest, resting HR and BP were measured using an automated monitor (Elite 7300IT, Omron Healthcare Inc, Lake Forest, IL, USA). Stature was determined with a stadiometer (213, Seca

Table 5.1. Descriptive characteristics of non-professional Latin dancers from London, UK.

	Total	Women (n = 11)	Men (n = 7)
Age (yr)	40 ± 9	42 ± 11	37 ± 4
BM (kg)	66.7 ± 9.8 *	62.0 ± 7.5	74.2 ± 8.6
BF (%)	22.5 ± 7.3 **	26.7 ± 4.8	15.9 ± 5.6
BMI (kg/m^2)	23.6 ± 2.6	23.4 ± 2.8	24.0 ± 2.3
VO_{2max} (mL/kg/min)	36.7 ± 8.5 **	32.0 ± 7.1	44.0 ± 3.7
VO_{2max} (percentile)	50 ± 20	45 ± 25	55 ± 20
Systolic BP (mmHg)	120 ± 10	119 ± 11	120 ± 8
Glucose (mmol/L)	4.9 ± 0.7	4.8 ± 0.6	5.1 ± 1.0
TC (mmol/L)	5.0 ± 0.8	5.2 ± 0.9	4.7 ± 0.6
Latin dance experience (yr)	6 ± 5	6 ± 6	5 ± 5
Latin dance frequency (h/wk)	5 ± 3	5 ± 3	5 ± 2

Data are presented as mean ± standard deviation; BF = percent body fat; BM = body mass; BMI = body mass index; BP = blood pressure; TC = total cholesterol; VO_{2max} = maximal oxygen uptake; * and ** indicate significant differences between sexes at $p < 0.01$ and $p < 0.001$, respectively.

Ltd, Birmingham, UK), and BM and BF were assessed using a multifrequency bioelectrical impedance analyser (MC 180MA, Tanita Europe BV, Amsterdam, Netherlands). Capillary blood samples were collected for measurement of glucose and total cholesterol (TC) using an automated analyser (Accutrend GC, Hoffman-La Roche Ltd, Basel, Switzerland). Latin dance experience and frequency were self-reported.

The graded exercise test was conducted on a treadmill (Venus, H/P/Cosmos Sports & Medical GmbH, Nussdorf, Germany) using the Bruce protocol[146] and was terminated when volitional exhaustion was reached. HR was measured via short-range radio telemetry (RS400, Polar Electro Oy, Kempele, Finland) and breath-by-breath pulmonary gas exchange data were collected using an indirect calorimeter (Oxycon Pro, Viasys Healthcare GmbH, Hoechberg, Germany). VO_{2max} was calculated by averaging the VO_2 data during the final 30 s of the test. A maximal effort was deemed to have been given if at least two of the following criteria were satisfied upon test termination: a plateau in VO_2 of < 150.0 mL/min; a respiratory exchange ratio of > 1.10, and a HR response within 10 beat/min of age-predicted HR_{max}. All dancers met at least two of the criteria. HR_{max} was taken as the highest HR

attained during the treadmill test. The dancers were then familiarised with the instruments for the study and instructed on their proper usage.

A triaxial accelerometer (wGT3X+ 2.0, ActiGraph LLC, Pensacola, FL, USA) with accompanying HR monitor was worn by the dancers (a complete description of which is presented in Section 3.3). The equipment allows continuous recording of both body acceleration and HR response, and is lightweight, small, and unobtrusive during dance performance. Furthermore, the equipment neither restricts body movement nor impedes the ability to dance normally.

Measurement of Latin dance state IM was undertaken using the four dimension IMI.[118] The questionnaire is scored on a Likert-type scale ranging from one (strongly disagree) to seven (strongly agree) and has been shown to have adequate internal consistency with Cronbach coefficient alphas of 0.80, 0.87, 0.84, and 0.68 for the dimensions of interest-enjoyment, perceived competence, effort-importance, and tension-pressure, respectively. The first three of these dimensions have been theorised to positively indicate IM, while, conversely, tension-pressure has been theorised to be a negative indicator of IM. The wording of the instrument was slightly altered to reflect the activity of dance.

PB of Latin dance were measured via the EBBS.[120] The questionnaire uses a four response Likert-type scoring system ranging from one (strongly disagree) to four (strongly agree). Only the perceived benefit items of the instrument were scored; barrier questions were ignored. PB are comprised of the following five factors: life enhancement; physical performance; psychological outlook (a state of improved mental health and well-being, experiencing a sense of enjoyment or accomplishment, or being relaxed and without feelings of stress or tension); social interaction; and preventative health. Internal consistency has been reported to be good, with a Cronbach coefficient alpha of 0.95 for the benefits component of the scale. Instructions were given to answer the questions in the context of the specific activity being researched (i.e., dance). The dancers completed the EBBS on a single occasion (the day of their laboratory visit) in order to capture general ideas relating to the PB of dance.

The dancers attended two Latin partnered social dance sessions in established salsa venues in London, UK over a 2 wk period. Each session was 2 h in length, and a recovery period of at least 48 h was taken between sessions. Instructions were given to perform euhydrated, at least 2 h postprandial, and to avoid strenuous PA in the 24 h preceding dancing. The salsa venues and session start times were self-selected by the dancers and were chosen to be representative of where and when they normally took part in the activity. Both sessions were performed at the same time of day (± 1 h). The dancers were instructed that only time spent in social dance would be eligible for analysis; participation in instructor-led group classes of Latin dance (which commonly precedes social dance time in many salsa venues) would have been unsuitable for this study as performance of dance under these conditions is not entirely self-selected. Additionally, the dancers were given specific instructions to treat the sessions as normal social dance events and to not alter their behaviour in any way due to attachment of the accelerometer and HR monitor. The dancers completed the IMI immediately following each session in order to capture their state IM for dance.

Calculations of EE, SC, HR, HRR, HRR_{max}, VM acceleration, PA volume, and time spent dancing were undertaken using the mean of the data collected during the two dance sessions. Mean values were used to minimise intraindividual variability. Time spent dancing was established by summing the VM acceleration data that corresponded to a PA intensity other than sedentary using dance-specific wrist location cut-points.[77] EE and SC during dance were computed using previously validated methods.[77] Laboratory-measured resting and HR_{max} were used to formulate HRR and HRR_{max} via the Karvonen method.[147] PA volume was calculated from time spent dancing, MET during dance (where 1 MET = 1 kcal/kg/h), and Latin dance frequency. Moderate and vigorous PA intensities were defined as 3.00 to 5.99 and ≥ 6.00 MET, respectively.[34] IM ratings were averaged between the sessions before analysis.

All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS 19.0, IBM Corp, Armonk, NY, USA). Independent *t*-tests were used to evaluate the descriptive characteristics and ascertain differences between female and male dancers. Differences between sexes in EE, SC, HRR, HRR_{max}, PA volume, and time spent dancing were also

determined using independent *t*-tests. Reliability of HR and VM acceleration between dance sessions was established using dependent *t*-tests. A two-way (sex x indicator) mixed ANOVA with repeated measures on the second factor was used to explore IMI ratings. Analysis of EBBS ratings was undertaken in a similar fashion to that of IM, except the within-subject factor was changed to perceived benefit. Positive indicators of IM were further examined using RM-ANOVA for each sex. Alpha was set at 0.05 and Bonferroni corrections were made for pairwise comparisons. Centrality and spread are presented as mean ± standard deviation with 95% CI reported where appropriate. Non-normally distributed data were assessed using non-parametric methods (i.e., Mann-Whitney tests).

5.4. Results

Physiological responses to Latin dance

Results of the Latin partnered social dance physiological assessment are presented (Table 5.2). In summary, during the 2 h session, no difference (p = 0.77) was observed between sexes for the total amount of time spent dancing, which was 80 ± 12 min. Total SC during dance was not different (p = 0.71) between female and male dancers; however, women expended a significantly lower ($p < 0.05$) total EE from dance, by an average of 172 [95% CI 30 – 314] kcal, when compared to men. No difference (p = 0.85) was revealed between sexes in accrued PA volume from dance.

When the dance session was examined for moderate intensity PA engagement, women spent a significantly greater ($p < 0.05$) amount of time dancing when compared to men (45 ± 6 versus 37 ± 9 min). The average difference was 6.6 [95% CI 0.4 – 12.7] % of the total session time, or 8 [95% CI 0 – 15] min. Female dancers were found to have a significantly lower ($p < 0.01$) EE, by an average of 0.34 [95% CI 0.16 – 0.51] kcal/kg/h, when compared to male dancers. Female dancers also demonstrated a significantly lower ($p < 0.001$) SC when compared to their male counterparts. The average difference was 3 [95% CI 1 – 4] step/min. No differences in HRR (p = 0.44) or HRR_{max} (p = 0.36) were found between sexes.

When examining the dance session for engagement in vigorous intensity PA, no differences were observed between female and male dancers in

Table 5.2. Physiological responses to Latin partnered social dance.

	Total	Women (n = 11)	Men (n = 7)
Two hour Latin dance session			
Time spent dancing (%)	66.3 ± 10.2	65.7 ± 11.2	67.2 ± 9.2
EE (kcal)	546 ± 160 *	479 ± 125	651 ± 159
SC (step)	9643 ± 1735	9514 ± 1741	9846 ± 1844
PA volume (MET h/wk)	20.7 ± 11.5	20.2 ± 11.7	21.3 ± 12.2
Moderate intensity PA engagement			
Time spent dancing (%)	35.1 ± 6.7 *	37.6 ± 5.0	31.1 ± 7.4
EE (kcal/kg/h or MET)	5.05 ± 0.23 **	4.91 ± 0.17	5.25 ± 0.16
SC (step/min)	115 ± 2 ***	114 ± 2	117 ± 0
HRR (%)	42.7 ± 9.5	45.0 ± 8.8	41.2 ± 10.1
HRR_{max} (%)	80.9 ± 12.6	83.2 ± 11.2	77.4 ± 14.7
Vigorous intensity PA engagement			
Time spent dancing (%)	31.1 ± 13.2	28.0 ± 12.5	35.9 ± 13.8
EE (kcal/kg/h or MET)	7.30 ± 0.27	7.27 ± 0.27	7.35 ± 0.29
SC (step/min)	130 ± 3	130 ± 3	131 ± 1
HRR (%)	55.5 ± 11.2	56.0 ± 11.2	54.6 ± 12.0
HRR_{max} (%)	81.5 ± 13.1	83.7 ± 11.2	78.0 ± 16.0

Data are presented as mean ± standard deviation; EE = energy expenditure; HRR = heart rate reserve; HRR_{max} = maximal heart rate reserve; MET = metabolic equivalents; PA = physical activity; SC = step count; *, **, and *** indicate significant differences between sexes at $p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively.

measures of time spent dancing ($p = 0.23$), which was 37 ± 16 min, EE ($p = 0.52$), SC ($p = 0.68$), HRR ($p = 0.80$), or HRR_{max} ($p = 0.38$).

Reliability of Latin dance sessions

Results of the VM acceleration reliability analysis indicated no difference ($p = 0.65$) between dance sessions (204 ± 37 and 208 ± 37 count/s for sessions 1 and 2, respectively). Furthermore, results of the HR reliability analysis also indicated no difference ($p = 0.84$) between dance sessions (121 ± 17 and 120 ± 15 beat/min for sessions 1 and 2, respectively).

Latin dance state IM

Ratings for the underlying dimensions of IM for Latin partnered social dance are presented (Table 5.3). Significant main effects of indicator ($p < 0.001$) and sex ($p < 0.05$) were revealed, with positive indicators rated higher than negative by an average of 2.40 [95% CI 2.00 – 2.81], and overall ratings

Table 5.3. Indicators of IM for Latin partnered social dance.

	Women (n = 11)	Men (n = 7)
Positive		
Interest-enjoyment	5.85 ± 0.82	6.27 ± 0.64
Perceived competence	5.62 ± 0.89	5.27 ± 0.78
Effort-importance	4.86 ± 0.94	5.38 ± 0.93
Average	5.44 ± 0.96	5.64 ± 0.88
Negative		
Tension-pressure	1.96 ± 0.67	3.27 ± 1.11
Average	1.96 ± 0.67	3.27 ± 1.11

Data are presented as mean ± standard deviation; IM = intrinsic motivation.

of male dancers scoring higher than those of female dancers by an average of 0.95 [95% CI 0.17 – 1.72]. No interaction (p = 0.07) was observed between the independent variables. Assessment of the individual dimensions positively indicating IM resulted in a significant main effect ($p < 0.05$) for both women and men. Dancers of both sexes considered interest-enjoyment to be the motivator of primary importance. Post hoc analyses revealed that interest-enjoyment was significantly higher ($p < 0.05$) than effort-importance by an average of 0.99 [95% CI 0.08 – 1.90] for female dancers. For male dancers, interest-enjoyment was significantly higher ($p < 0.05$) than perceived competence by an average of 1.00 [95% CI 0.24 – 1.76]. No other differences (all $p > 0.05$) were found between the individual dimensions.

Latin dance PB

Perceptions of the benefits of Latin partnered social dance are presented (Table 5.4). Significant main effects ($p < 0.001$) of benefit and sex were revealed; however, no interaction effect (p = 0.39) was present. Both females and males considered psychological outlook to be the dance-related benefit of greatest importance. Post hoc tests indicated that psychological outlook was significantly higher ($p < 0.001$) than life enhancement by an average of 0.66 [95% CI 0.38 – 0.93], physical performance by an average of 0.61 [95% CI 0.25 – 0.97], and preventative health by an average of 0.79 [95% CI 0.36 – 1.22]. Furthermore, social interaction was found to be significantly higher ($p < 0.05$) than life enhancement by an average of 0.45 [95% CI 0.06 – 0.84] and preventative health by an average of 0.58 [95% CI 0.05 – 1.11]. No other differences were observed between the PB. It was revealed that women

Table 5.4. PB of Latin partnered social dance.

	Women (n = 11)	Men (n = 7)
Benefit		
Life enhancement	3.03 ± 0.42	2.72 ± 0.45
Physical performance	3.17 ± 0.56	2.66 ± 0.49
Psychological outlook	3.67 ± 0.33	3.45 ± 0.41
Social interaction	3.32 ± 0.48	3.32 ± 0.51
Preventative health	2.91 ± 0.58	2.57 ± 0.69
Average	3.22 ± 0.35	2.94 ± 0.40

Data are presented as mean ± standard deviation; PB = perceived benefits.

demonstrated significantly higher ($p < 0.001$) perceptions of the benefits of dance, by an average of 0.29 [95% CI 0.09 – 0.66], when compared to men.

5.5. Discussion

The purpose of this investigation was to evaluate the physiological and perceptual responses to Latin partnered social dance. The principal findings were that, Latin dance to salsa music demands MVPA intensity levels when engaged in as a self-selected activity within an ecologically valid setting, and further, fosters interest, enjoyment, and a positive psychological outlook among novice to advanced non-professional Latin dancers taking part primarily for leisure purposes.

As expected, male dancers displayed higher VO_{2max}, BM, and lower BF, when compared to female dancers. Laboratory-measured VO_{2max}, an indicator of cardiorespiratory fitness, was found to be of average level for both the female and male non-professional Latin dancers in the present study in comparison with normative data.[148] Despite having only average cardiorespiratory fitness, the dancers in this investigation fared better in all four of the metabolic risk factors for non-communicable disease (BMI, systolic BP, glucose, and TC) than the 2011 UK population figures reported by the WHO.[1] This, of course, we cannot attribute solely to participation in dance as the design of our study was observational in nature; however, sufficient PA[12] has consistently been shown to be negatively correlated with the development of obesity, hypertension, glucose intolerance, and dyslipidaemia in otherwise healthy adults.[34]

The dancers in the current work accrued a total dance-related PA volume of 20.7 MET h/wk. Leisure activities of moderate to vigorous intensity have been shown to be substantially beneficial for adults in terms of decreased mortality risk and improved life expectancy.[149] In a pooled prospective cohort analysis of 650,000+ women and men aged 21 to 90 yr, Moore and colleagues[149] demonstrated that individuals taking part in 15.0 to 22.4 MET h/wk of moderate to vigorous intensity leisure PA increased life expectancy by 4.2 [95% CI 4.0 – 4.5] yr. The accrued PA volume from dance observed in this investigation, even after exclusion of non-dancing time, was more than double the WHO-recommended level for adults aged 18 to 64 yr.[12,149] These findings are especially intriguing considering that data were collected within an ecologically valid setting with results indicating that dancers who took part in this activity did so for reasons other than for physical health gains.

The fraction of the total time spent engaged in dance was quantified via motion sensing technique. This measurement is of particular importance as Latin partnered dance is essentially a self-selected activity with performance involving a certain degree of improvisation when undertaken socially. It was found that one third of social dance time was spent not dancing; however, the remainder of the time yielded slightly less than 10,000 step taken by both female and male dancers. This number of steps has been suggested to be a reasonable target for adults seeking to meet recommended guidelines for daily PA involvement for the maintenance of health.[144] This study is also the first to report measurement of stepping cadence during Latin partnered social dance, which ranged from 114 to 131 step/min, a value well above the intensity of 100 to 110 step/min demonstrated to be the equivalent of moderate intensity walking.[150] Accelerometer-determined steps have been shown to be negatively associated with cardiovascular disease risk, whereby each 1000 step increment in daily SC resulted in a reduced odds of metabolic syndrome development of 10 to 13% for both women and men.[151]

Although a target EE of ~1000 kcal/wk from PA is recommended for the general adult population, recent evidence suggests that a reduced risk of cardiovascular disease and premature mortality actually begins at an EE of ~500 kcal/wk.[34] This value is similar to the total EE observed in the present study following 2 h of social dance time. Interestingly, relative EE during

dance ranged from 4.91 to 7.35 kcal/kg/h, which is higher than the results reported by Emerenziani and colleagues[26] (3.90 to 5.50 MET; where 1 MET = 1 kcal/kg/h). This discrepancy is likely due to the different techniques used for EE determination. The aforementioned study was conducted using HR recording and a non-dance-specific value calibration procedure. In contrast, EE in this study was derived using a previously validated dance-specific combined accelerometry and HR technique that has been shown to predict EE during dance more accurately than the use of HR alone.[77]

In adults of approximately the same age as the dancers in this study, Hanrahan and colleagues[64] examined IMI responses to instructor-led group classes of Latin dance. All three of the positive indicators of IM were rated similarly as those reported in this study, suggesting that novice to advanced dancers engaging in Latin dance primarily for leisure purposes are equally intrinsically motivated during both class time and social dance time. Whether this remains the same when physically inactive and inexperienced individuals take up dance for health-related purposes is yet to be investigated. Tension-pressure was also rated similarly between the two studies for male dancers. Female dancers, however, in the present investigation had a considerably lower tension-pressure rating when compared to the results of Hanrahan and colleagues.[64] This is likely a result of autonomy during instructor-led group classes, in comparison with social dancing, being lower due to the nature of the teaching/learning environment. The current work demonstrates the contribution that interest and enjoyment make to IM for leisure PA. The importance of IM in terms of PA adherence, and in turn its PB, is well established in the literature.[6]

In a study comprising two hundred physically inactive women,[152] it was shown that the PB of traditional exercise, measured via the EBBS, were rated lower than the benefit scores reported in the present investigation for female dancers. This suggests that women who take part in Latin dance perceive greater benefits from engagement in this activity than physically inactive women do from traditional exercise, a result possibly due to the social nature of this particular dance genre. Additionally, it was reported that physically inactive mothers rated the EBBS factors of life enhancement and social interaction as highest and lowest, respectively, during a 12 wk exercise

intervention.[153] These results are in contrast to the findings presented here. Moreover, the authors of the aforementioned research suggested that the most beneficial aspects of exercise were improved alertness, fatigue, and sleep. The women in this investigation, however, considered there to be a substantial psychosocial component involved during engagement in Latin dance. This psychosocial benefit likely plays an important contributing role in why individuals choose to pursue this particular activity.

Although our work indicates that Latin dance to salsa music is a holistic pursuit with the potential to positively affect both physical and mental health, there are certain limitations that must be recognised. Firstly, our observational research design did not use a reference or control condition, and secondly, we did not ask the dancers to self-report lifestyle factors such as engagement in other forms of PA. Accordingly, these findings should be interpreted cautiously if attempting to make inferences to physically inactive individuals with no previous experience in dance.

Adults seeking to become more physically active could select this particular genre of dance to take part in as engagement over two sessions weekly would mean meeting the PA guidelines for physical and psychosocial health maintenance.[12,34,141] Moreover, our findings indicate that Latin dance fosters a positive psychological outlook alongside feelings of interest and enjoyment. Practitioners interested in the efficacy of Latin social dancing as an expressive medium for the promotion of health may find these results intriguing. The application of combined HR and movement registration to evaluate physiological load during dance is a new technique that shows promise not only for the purposes of health promotion through dance, but also potentially for other dance genres and contexts as well.

6 STUDY 3

6.1. Title

Salsa dance and Zumba fitness: acute responses during community-based classes.

6.2. Introduction

Physical inactivity has a prevalence in high-income nations of 48 and 41% for women and men, respectively.[154] Adults who decrease sedentary time while increasing MVPA reap the rewards of a reduced likelihood for non-communicable disease.[12] Furthermore, PA, especially leisure pursuits undertaken in socially rich environments, can benefit mental health in adults[141] as engagement has been shown to be inversely associated with depressive-[155,156] and anxiety-related symptoms.[157] PA has also been posited to be an efficacious strategy for the enhancement of psychological well-being, in part, due to the relationship between PA and positive affect.[39]

With respect to physical and psychosocial health promotion, one particular activity, Latin dance, has been examined for its potential as a community-based health-enhancing PA for adults.[21,71,72] It has been suggested that this genre of dance could play a viable role in the engagement of individuals in physically active pursuits that are not necessarily thought of as traditional exercise per se.[4] Research interest in both partnered Latin dance (i.e., salsa)[78] and non-partnered Latin-themed aerobic dance (i.e., Zumba fitness)[74] has increased in recent years, likely a result of the gaining popularity of these types of instructor-led group classes among the mainstream dance and fitness audiences.[4,28] However, despite these activities being seemingly divergent, in many countries around the world both salsa dance and Zumba fitness are popular leisure pursuits engaged in by members of both the Latin and non-Latin communities. Moreover, organisations in the health and arts sectors continue to promote dance as a potentially practical and sustainable

way of enhancing health in adults through non-traditional modalities of PA engagement.[158]

We recently undertook two investigations using objective measurement techniques to assess the physiological parameters of Latin dance in novice to advanced non-professional Latin dancers.[77,78] It was found that performance in a real environment involves being engaged in dance for only two thirds of the total time spent during social dancing.[78] Thus, the time effectiveness of this activity could be called into question if investigating this particular genre of dance in the context of PA promotion. Furthermore, it is imperative to evaluate the responses to dance in a community sample of physically inactive adults, as these individuals are targeted most often in PA campaigns. PA type is also an important consideration in the selection of a health-oriented leisure pursuit as adherence is likely maintained only when participation is perceived to be enjoyable,[159] offers opportunity for skill mastery, fosters a self-regulated experience, and provides a sense of connectedness with others.[7] Both Latin dance and Latin-themed aerobic dance, arguably, address each of these elements of the self-determination theory[7] well.

Despite awareness of the likely physical and mental health-promoting properties of dance, no investigations have yet explored the simultaneous physiological responses and psychological experiences during community-based classes of salsa dance and Zumba fitness using validated dance- and exercise-specific instruments. Moreover, potential relationships between physical and mental health-related outcomes, which may indeed exist in both salsa dance and Zumba fitness and be relevant for a holistic understanding of these activities, remain largely unexplored. Hence, the purpose of this study was to simultaneously assess the physiological responses and psychological experiences during instructor-led group classes of Latin dance and Latin-themed aerobic dance in a community sample of physically inactive women. We sought to determine differences between classes of salsa dance (partnered and attended primarily for development of dance technique) and Zumba fitness (non-partnered and attended primarily for exercise purposes) in order to establish the efficacy of these activities for the purposes of community-based PA and psychosocial health promotion.

6.3. Methods

Recruitment was undertaken using poster advertisements placed in the Royal Borough of Kingston and the surrounding communities of London, UK. Twenty-four women (age 36 ± 11 yr, age range 22 to 56 yr, BM 62.2 ± 8.7 kg, BF 28.1 ± 5.5%, BMI 23.1 ± 2.8 kg/m^2, VO_{2max} 30.5 ± 4.7 mL/kg/min) volunteered to participate in this study, which had been approved by the Faculty Ethics Committee at Kingston University and was conducted in accordance with the Declaration of Helsinki. All participants were novice to intermediate non-professional performers of Latin dance and/or Latin-themed aerobic dance. The participants gave their informed consent in writing before the commencement of the study and after the experimental procedures, risks, and benefits of participation had been explained. Inclusion criteria stated that the participants must be female, aged 18 to 64 yr, physically inactive (≤ 1 day/wk of MVPA engagement for no more than 30 min), free from musculoskeletal injury, and able to adhere to the study protocol safely. Although a total of twenty-six women consented to enrol in the study, two were not able to complete the research due to unavoidable work commitments and were therefore excluded from the data analysis.

Instructions were given to the participants to arrive at the laboratory euhydrated and at least 2 h postprandial. Following 15 min of seated rest, resting HR was measured using an automated monitor (Elite 7300IT, Omron Healthcare Inc, Lake Forest, IL, USA). Stature was determined with a stadiometer (213, Seca Ltd, Birmingham, UK), and BM and BF were assessed using a multifrequency bioelectrical impedance analyser (MC 180MA, Tanita Europe BV, Amsterdam, Netherlands). The participants performed a graded exercise test, as described previously,[78] for determination of VO_{2max} and HR_{max}. The participants were then familiarised with the instruments for the study and instructed on their proper usage.

A triaxial accelerometer (wGT3X+ 2.0, ActiGraph LLC, Pensacola, FL, USA) with accompanying HR monitor was worn by the dancers (a complete description of which is presented in Section 3.3). The utility of this equipment for dance has been described in detail elsewhere.[78]

Psychological experiences were measured via the three factor SEES[121] immediately before commencement and after completion of each class. The

questionnaire uses a Likert-type scoring system ranging from one (not at all) to seven (very much so) with a midpoint anchor at four (moderately). Internal consistency has been reported to be high, with Cronbach coefficient alphas of 0.86 and 0.85 for PWB (great, positive, strong, terrific; a preponderance of positive affect and high life satisfaction, or flourishing[160,161]) and PD (awful, crummy, discouraged, miserable), respectively. Items pertaining to fatigue were not scored. The wording of the instrument was slightly altered to reflect the class types (i.e., salsa dance and Zumba fitness) and time points being investigated.

The participants attended two partnered salsa dance and two non-partnered Zumba fitness classes each in a counterbalanced order over a 2 wk period. The instructor-led group classes were taught by certified salsa dance and Zumba fitness teachers. Each class was 1 h in length and a recovery period of at least 48 h was taken between classes. Instructions were given to perform euhydrated and at least 2 h postprandial. The classes were attended at the same time of day (± 1 h). The participants were given specific instructions to treat the classes as normal dance sessions and to not alter their behaviour in any way due to attachment of the accelerometer and HR monitor.

In a typical salsa dance class, development of dance technique is the primary emphasis. About half of each class is spent in partner work, with men being taught how to lead the figures and women being instructed on appropriate following and styling skills. A warm-up song and three to four practise songs are typically played during a 1 h session. Class structure and selection of music, including song tempo, which affects dance intensity,[77] are determined by the instructor. Zumba fitness classes, in contrast, typically focus on larger upper and lower body movements as the primary purpose is aerobic exercise. Less attention is placed on correct execution of the formal dance steps. Song selection (both Latin and international) is again at the discretion of the instructor. A typical 1 h Zumba fitness class consists of one to two warm-up songs, followed by eight to ten main songs choreographed to elicit both low and high intensities of dance. Sessions conclude with one to two songs used for cool-down and stretching.

Calculations of EE, SC, HR, HRR, HRR_{max}, VM acceleration, and time spent in sedentary, light, moderate, and vigorous intensity PA during salsa

dance and Zumba fitness were undertaken using the mean of the data collected during the respective classes. Mean values were used to minimise intraindividual variability. Sedentary time was established by summing the VM acceleration data that corresponded to a PA intensity of ≤ 1.49 MET using the dance-specific wrist location cut-point of ≤ 74 count/s.[77] EE, SC, and time spent in light, moderate, and vigorous intensity PA were computed from the combined HR and VM acceleration data using the previously validated dance-specific wrist location equations of Domene and Easton[77]: EE (kcal/kg/h or MET) = 1.363757 + (0.010282 x WRI) + (0.017040 x HR) and SC (step/min) = 97.614892 + (0.072519 x WRI) + (0.051282 x HR). For the above equations, WRI = vector magnitude acceleration of the wrist in count/s and HR = heart rate in beat/min. Laboratory-measured resting and HR_{max} were used to formulate HRR and HRR_{max} via the Karvonen method.[147] SEES ratings for salsa dance and Zumba fitness were averaged between the respective classes before analysis.

All statistical analyses were conducted using the programming language R (R 3.0, The R Foundation for Statistical Computing, Vienna, Austria). Differences between class types in EE, SC, HRR, HRR_{max}, and time spent in sedentary, light, moderate, and vigorous intensity PA were determined using dependent *t*-tests. Reliability of HR and VM acceleration between classes was also established using dependent *t*-tests. Relationships between the psychological experiences and total EE, total SC, and total time spent in MVPA were assessed with Spearman's correlation coefficients, ρ. A two-way (class type x time point) repeated measures analysis of covariance (RM-ANCOVA) was used to explore each SEES factor. The average pre-class SEES score was used as the covariate in the models and dependent *t*-tests were used to ascertain differences between pre-class psychological experience ratings. Alpha was set at 0.05. Centrality and spread are presented as mean ± standard deviation with 95% CI reported where appropriate. Non-normally distributed data were assessed using non-parametric methods (i.e., Wilcoxon signed-rank tests).

6.4. Results

Psychological experiences during Latin dance and Latin-themed aerobic dance

Results of the salsa dance and Zumba fitness psychological assessment are

Table 6.1. Psychological experiences during 1 h instructor-led group classes of salsa dance and Zumba fitness (*N* = 24).

	Pre-class	Post-class
PWB		
Salsa dance	16.35 ± 3.69	20.73 ± 3.03
Zumba fitness	15.56 ± 3.29	20.46 ± 3.04
PD		
Salsa dance	7.54 ± 3.68	5.98 ± 1.98
Zumba fitness	8.92 ± 4.69	6.33 ± 2.42

Data are presented as mean ± standard deviation; PD = psychological distress; PWB = positive well-being.

presented (Table 6.1). There was no difference (all $p > 0.05$) in pre-class ratings of PWB and PD between class types. However, a significant main effect of time point was obtained for both PWB ($p < 0.01$, partial $\eta^2 = 0.41$) and PD ($p < 0.001$, partial $\eta^2 = 0.72$). For both SEES factors, neither the main effect of class type nor the interaction reached significance (all $p > 0.05$).

Physiological responses to Latin dance and Latin-themed aerobic dance

A significantly lower ($p < 0.001$) amount of sedentary time was observed during Zumba fitness when compared to salsa dance (8.6 ± 3.0 versus 27.2 ± 6.0 min). During light intensity PA engagement no difference ($p = 0.62$) was observed between class types (0.3 ± 0.6 versus 0.3 ± 0.5 min). The amount of time engaged in moderate intensity PA was also significantly lower ($p < 0.001$) during Zumba fitness in comparison with salsa dance (14.7 ± 5.5 versus 22.5 ± 4.2 min). In contrast, vigorous intensity PA time was significantly greater ($p < 0.001$) during Zumba fitness when compared to salsa dance (36.5 ± 7.5 versus 10.2 ± 4.3 min).

Results of the salsa dance and Zumba fitness physiological assessment are presented (Table 6.2). When examining the instructor-led group classes for MVPA, both EE and SC were significantly higher ($p < 0.001$) during Zumba fitness in comparison with salsa dance. Measures of HRR and HRR_{max} were also both significantly higher ($p < 0.001$) in Zumba fitness when compared to salsa dance. Measures of total EE and total SC for salsa dance and Zumba fitness are presented (Figures 6.1 and 6.2, respectively). There was a significantly higher ($p < 0.001$) total EE and total SC revealed during Zumba

Table 6.2. Physiological responses to 1 h instructor-led group classes of salsa dance and Zumba fitness (*N* = 24).

	Salsa dance	Zumba fitness
MVPA		
EE (kcal/kg/h or MET)	5.50 ± 0.28	6.21 ± 0.32 *
SC (step/min)	119 ± 2	122 ± 2 *
HRR (%)	34.5 ± 9.2	57.0 ± 12.5 *
HRR_{max} (%)	63.7 ± 13.0	86.6 ± 12.0 *

Data are presented as mean ± standard deviation; HRR = heart rate reserve; HRR_{max} = maximal heart rate reserve; MET = metabolic equivalents; MVPA = moderate to vigorous physical activity; SC = step count; * indicates a significant difference between class types at $p < 0.001$.

fitness, by an average of 201 [95% CI 173 – 229] kcal and 2665 [95% CI 2244 – 3086] step, respectively, in comparison with salsa dance. The HR response and VM acceleration of a representative individual participant during salsa dance and Zumba fitness are presented (Figures 6.3 and 6.4, respectively).

Correlation of Latin dance and Latin-themed aerobic dance psychological experiences

During Zumba fitness, a significant relationship ($\rho = 0.39$, $p < 0.05$) was found between the change score in PWB and total EE. Similarily, a significant negative relationship ($\rho = -0.63$, $p < 0.01$) was revealed between the PD change score and total EE during Zumba fitness. No further associations (all $p > 0.05$) were observed between the SEES factor change scores and total SC and total time spent in MVPA during Zumba fitness. For salsa dance, there were no relationships (all $p > 0.05$) between the psychological experiences and physiological responses recorded.

Reliability of accelerometry and HR for Latin dance and Latin-themed aerobic dance

Results of the reliability analysis for VM acceleration during salsa dance indicated no difference ($p = 0.21$) between classes (127 ± 28 and 132 ± 36 count/s for classes 1 and 2, respectively). There was also no difference ($p = 0.27$) in VM acceleration between Zumba fitness classes (317 ± 67 and 325 ± 58 count/s for classes 1 and 2, respectively). Results of the HR reliability analysis for salsa dance indicated no difference ($p = 0.48$) between classes (107 ± 16 and 106 ± 17 beat/min for classes 1 and 2, respectively). Moreover, no

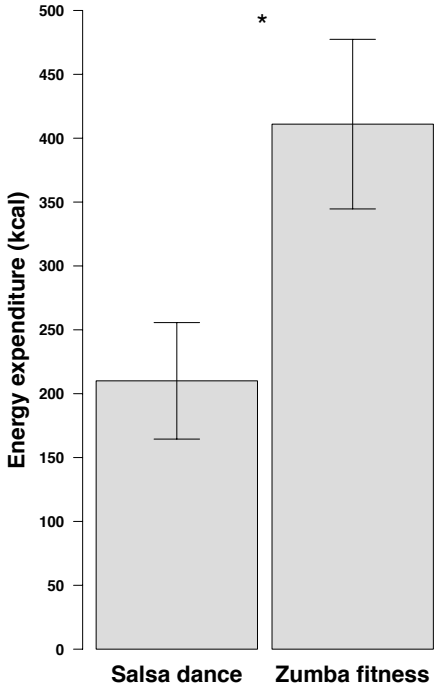

Figure 6.1. Total energy expenditure during 1 h instructor-led group classes of salsa dance and Zumba fitness (*N* = 24). Data are presented as mean ± standard deviation; * indicates a significant difference between class types at *p* < 0.001.

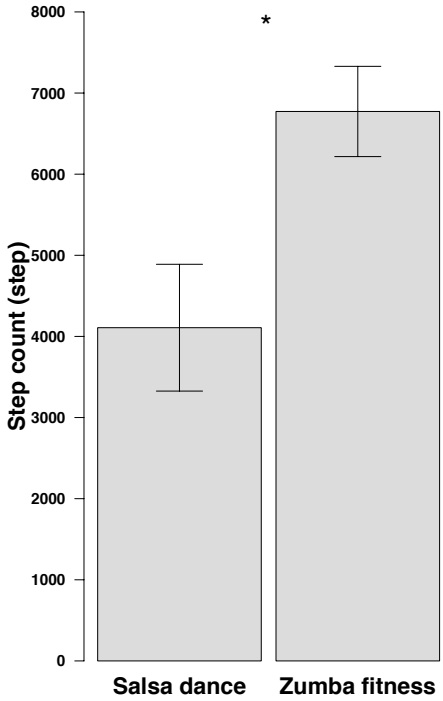

Figure 6.2. Total step count during 1 h instructor-led group classes of salsa dance and Zumba fitness (*N* = 24). Data are presented as mean ± standard deviation; * indicates a significant difference between class types at *p* < 0.001.

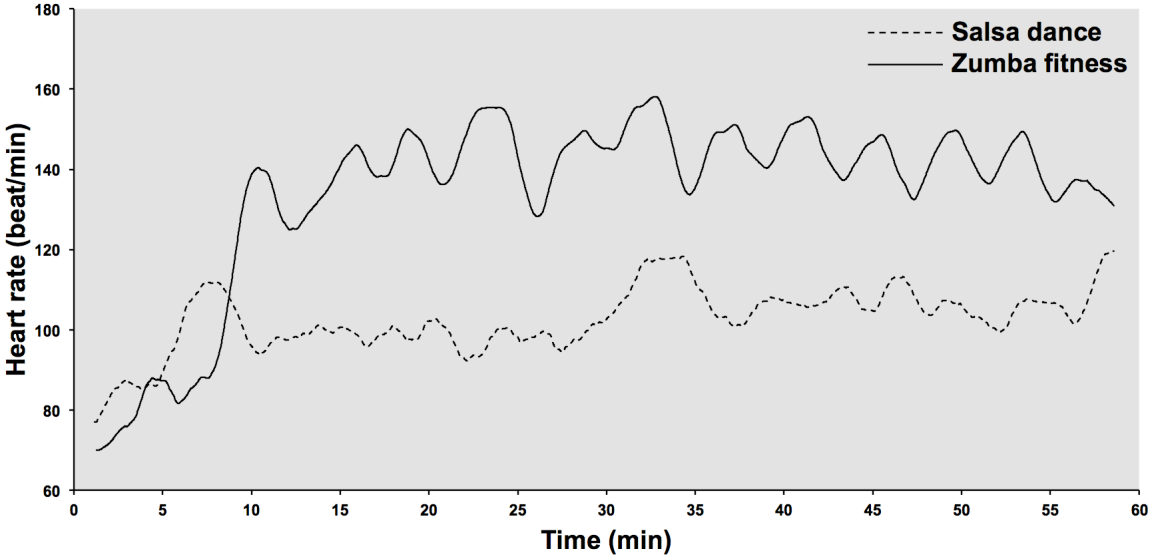

Figure 6.3. Smoothed heart rate response of a representative individual participant during 1 h instructor-led group classes of salsa dance and Zumba fitness.

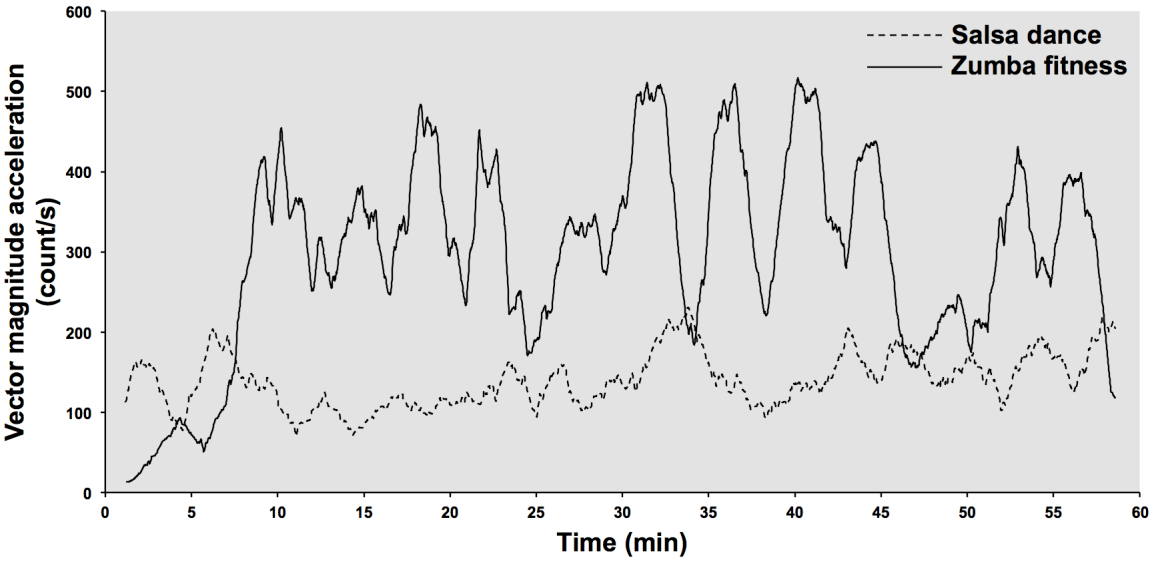

Figure 6.4. Smoothed vector magnitude acceleration of a representative individual participant during 1 h instructor-led group classes of salsa dance and Zumba fitness.

difference ($p = 0.26$) was revealed in HR between Zumba fitness classes (139 ± 18 and 137 ± 17 beat/min for classes 1 and 2, respectively).

6.5. Discussion

The current work used validated dance- and exercise-specific methods to compare the HR response, caloric output, steps taken, and activity engagement time of salsa dance and Zumba fitness in a community-recruited cohort of physically inactive individuals, while concurrently exploring short-term change in levels of distress and well-being. For both types of dance classes, more than half of the total time was spent in MVPA with Zumba fitness yielding a total EE almost double that of salsa dance. Improvements in PWB and PD of a large magnitude[162] were observed pre- to post-class. We also report, in Zumba fitness, medium to large strength[132] relationships between caloric output and increased well-being and reduced distress.

This investigation demonstrated that PWB increased acutely during dance, irrespective of whether the class type was intended principally for exercise purposes or development of dance technique. Similarly, in an 8 wk Zumba fitness study[67] it was shown that women improved in measures of well-being from pre- to post-intervention. The effect size (0.45) was marginally greater than that reported in this study. Kim and Kim[65] administered the SEES to evaluate the exercise experiences of two hundred seventy-seven adults and found comparable pre- to post-class improvements in both PWB (increase = 3.10) and PD (decrease = 2.70) for participants randomly assigned to aerobic dance. Intriguingly, no significant improvements in these factors were observed in the traditional exercise (weight training, jogging, and flexibility) group. In a systematic review using meta-analytic methods, Chida and Steptoe[37] revealed that well-being was associated (hazard ratio = 0.82 [95% CI 0.76 – 0.89]) with reduced mortality in 36,000+ healthy individuals. Hence, it is likely that psychosocially-oriented PA campaigns would benefit from incorporation of well-being enhancing activities, for example dance.

In a randomised controlled trial of adults experiencing depressive- or stress-related symptoms, it was revealed that partnered Latin dance reduced levels of depression (effect size = 0.50) and psychological stress (effect size = 0.45) post-intervention.[21] The results of the current work, similarly, indicated that partnered Latin dance lowered PD in physically inactive, but otherwise

healthy, adults. Experiencing an acute reduction in distress after attending a dance class may facilitate activity adherence, which is likely especially important for physically inactive individuals. Currently, however, a lack of consensus exists regarding the exact mechanisms by which exercise and leisure activities, such as dance, exert their mental health-enhancing effect, although evidence suggests that numerous psychological, physiological, and biochemical processes are likely involved.[33,156,163]

It was demonstrated that six months of attendance in community-based Latin dance classes increased vigorous intensity PA in women.[71] As these data were estimated via self-report questionnaire, our own investigation lends support to the findings of Hovell and colleagues[71] as we present objectively measured time spent at each individual PA intensity for both salsa dance and Zumba fitness. Furthermore, accelerometer-determined MVPA during 1 h classes of Latin dance has previously been reported to be 8.5 ± 6.4 min.[72] This value is substantially lower than what was found in the present study. The discrepancy may be explained by the fact that the cut-point system used by Lee and colleagues[72] was not developed specifically for the activity of dance, or that the 10 s accelerometer epochs selected were not responsive enough for this particular genre of dance.

The HR response during instructor-led group classes of Zumba fitness was shown to be 136 ± 17 beat/min in women aged 46 ± 10 yr,[74] a result marginally lower than that found in the present study. This difference is likely attributable to the age of the individuals who took part in our research, as the women were 10 yr younger (and of a similar cardiorespiratory fitness) than those recruited by Barene and colleagues.[74] The age-related decline in the HR response to physical work is well established[164] and likely plays a role in why exercise intensity (and therefore EE) during instructor-led group classes of aerobic dance has been shown to vary dramatically between individuals.[165] Moreover, it is already known that both previous experience and cardiorespiratory fitness affect the physiological responses during aerobic dance.[92,165] Thus, inferences to a general population (i.e., untrained and older) should be made cautiously when examining the effects of Zumba fitness measured in samples of professional instructors (experience = 2 – 6 yr)[88] or young adults (age = 19 ± 1 yr).[89]

When the participants in the current research undertook the classes of salsa dance, no relationships were established between the physiological responses and psychological experiences measured. A possible explanation for this may be the fact that the intentions or goals of the participants at the time were oriented towards improvement of dance technique, as opposed to being exercise-related. As salsa dancing is usually performed as a partnered dance between a leader and follower,[24] inherently, a strong social element exists when taking part. As the psychosocial benefits of salsa dance have been rated higher by women than the physical benefits,[78] it is plausible that the participants in this study may not have considered the salsa dance classes to be actual exercise sessions per se. An improved post-class affective state would therefore not necessarily be expected to be related to caloric output or vigorous activity. In contrast, the principal purpose of instructor-led group classes of aerobic dance for women likely is to do with exercise. Patel and Kasiram[166] reported that women engage in aerobic dance for exercise-related benefits more so than they do for the psychosocial reasons. Accordingly, it is not surprising that associations were found between total EE and increased PWB, and total EE and decreased PD, in the Zumba fitness condition only. These correlations may, in part, be due to Zumba fitness generally being perceived to be formal exercise,[29] which is not the case for salsa dance.[158] Consequently, the participants may have expected physically demanding Zumba fitness classes and it is plausible that these expectations were fulfilled as a result of the vigorous intensity elicited. Those who felt they had a high caloric output may in turn have experienced feelings of satisfaction or goal attainment, hence the observed concomitant improvement in affective state. It should be noted, however, that the interindividual differences in dance class expectations are likely to be considerable when sampling from a population of non-professional dancers, as was the case in this study.

Although this investigation is the first research we are aware of that concurrently explored both physiological and psychological aspects of salsa dance and Zumba fitness using activity-specific methods within an ecologically valid environment, there are two important limitations worth noting. Firstly, as we did not make use of a control group, it is therefore difficult to make inferences from our findings regarding causality. It would be prudent for

researchers in the future to further assess the efficacy of Latin dance and Latin-themed aerobic dance by utilising true experimental (i.e., randomised controlled trial) designs, objective measurement techniques validated specifically for the activity of dance, and naturalistic settings in which to undertake data collection. Secondly, it should be acknowledged that as no follow-up measures were taken in the present study, it is impossible to discern the time course over which the improvements in affective state lasted.

The physically inactive women who took part in this research expended ~200 – 400 kcal, took ~4000 – 7000 step, spent > 30 min in MVPA, and markedly improved measures of both well-being and distress during attendance in 1 h classes of dance. As such, we suggest that engagement in either partnered salsa dance for the improvement of dance technique or non-partnered Zumba fitness for the purposes of aerobic exercise is indeed efficacious in terms of community-based PA and psychosocial health promotion. The Zumba fitness classes yielded a higher EE, SC, MVPA, and HR response and VM acceleration (as shown in Figures 6.3 and 6.4, respectively) when compared to the salsa dance classes of comparable session time. We would further argue that Zumba fitness can be characterised as an intermittent and higher intensity activity than salsa dance. Hence, at least from an exercise-oriented perspective, it would seem that classes of Zumba fitness likely confer greater physiological benefit than classes of salsa dance.

7 STUDY 4

7.1. Title

The health-enhancing efficacy of Zumba fitness: an 8 wk randomised controlled study.

7.2. Introduction

The salutary effects of regular PA on physical[12] and mental[33] health are well-established and convincing. Of concern to PA investigators is the fact that half the adult populace remains physically inactive.[1] Recent cross-sectional research has demonstrated association between accelerometer-determined PA and improved cardiovascular risk factors[112] and HRQoL.[69] Aerobic dance, a popular type of PA engaged in primarily by women,[167] has been associated with acutely enhanced mood[62] and lowered likelihood of inflammatory biomarker elevation when compared to traditional (i.e., cycling and weight training) exercise.[45] A prospective cohort analysis of 27,000+ women indicated that cardioprotection afforded through PA was mediated largely by inflammatory biomarkers, BP, blood lipids, and BMI.[43] Recent PA research utilising specifically Latin-themed aerobic dance has shown post-intervention improvements in both BMI and BP in overweight[75] and obese[76] women, respectively.

We recently demonstrated that combined accelerometry and HR telemetry can provide a valid and reliable physiological assessment of Latin dance parameters under laboratory-based[77] and naturalistic settings in recreational dancers[78] and physically inactive women.[79] Zumba fitness, a form of Latin-themed aerobic dance, is currently practised by an estimated 14 million people in over 150 countries,[29] yet minimal evidence from randomised controlled studies[67,75] exists to substantiate its purported health-enhancing efficacy. The physiological effect of Zumba fitness on change in inflammatory biomarkers and cardiovascular risk factors remains unclear. Furthermore,

evidence to support the potential of Zumba fitness in improving mood and HRQoL over time among community-based physically inactive women is also lacking.

Consequently, we conducted a randomised controlled study of Zumba fitness in a community-recruited cohort of overweight and physically inactive women, as these individuals are commonly targeted in PA and psychosocial health promotion campaigns. Outcome measures were VO_{2max}, inflammatory biomarkers (CRP, IL-6, and WBC), cardiovascular risk factors (cholesterol, BP, BMI, and BF), mood, and HRQoL.

7.3. Methods

Rolling recruitment was undertaken using poster advertisements placed in the Royal Borough of Kingston and the surrounding communities of London, UK. The study had been approved by the Faculty Ethics Committee at Kingston University and was conducted in accordance with the Declaration of Helsinki. The participants gave their informed consent in writing before the commencement of the study and after the experimental procedures, risks, and benefits of participation had been explained.

Inclusion criteria stated that the participants must be female, aged 18 to 64 yr, physically inactive (≤ 1 day/wk of MVPA for no more than 30 min), inexperienced at Zumba fitness (≤ one class previously attended), overweight (BMI ≥ 25.0 kg/m^2), free from musculoskeletal injury, and able to adhere to the study protocol safely. Participants were excluded if they were: cigarette smokers; pregnant; recovering from a major injury or illness; using anti-inflammatory, hyperlipidaemia, or hypertension medication; or taking medication for anxiety- or depressive-related reasons.

Between August 2013 and March 2014, a total of ninety-seven women expressed interest in volunteering for the study. Seventy-four were deemed to be ineligible for enrolment due to the criteria specified for inclusion and exclusion. The remaining twenty-three consented to enrol in the study and were randomised to either the intervention or control group using a web-based random number generator (randomizer.org). One control and two intervention participants did not return for the post-intervention assessment due to unavoidable work commitments or unspecified personal illness and were

therefore excluded from the data analysis. The final sample comprised twenty women, aged 20 to 61 yr.

A two group randomised controlled study was employed with measures taken at pre-intervention (wk 0), post-intervention (wk 8), and follow-up (wk 16). Laboratory assessments were conducted prior to and following an 8 wk period of attendance in classes of Zumba fitness (intervention) or habitual activity (control) with anthropometric, physiological, inflammatory, mood, and HRQoL measures recorded. At follow-up, only mood and HRQoL were evaluated.

The participants visited the laboratory at 9:00 a.m. following an overnight fast and were asked to arrive in a euhydrated state. After 15 min of seated rest, resting HR and BP were measured using an automated monitor (Elite 7300IT, Omron Healthcare Inc, Lake Forest, IL, USA). Readings were obtained in duplicate and mean values were used for data analysis. Stature was determined with a stadiometer (213, Seca Ltd, Birmingham, UK), and BM and BF were assessed using a multifrequency bioelectrical impedance analyser (MC 180MA, Tanita Europe BV, Amsterdam, Netherlands). BF measurements from this analyser have been significantly correlated with measurements taken using dual energy X-ray absorptiometry.[114]

Blood samples were obtained from the median cubital vein by trained phlebotomists using a 23 gauge vacutainer push button blood collection system (368656, BD Diagnostics Ltd, Oxford, UK). A 5 mL serum separation tube (367986, BD Diagnostics Ltd, Oxford, UK) was filled and then inverted five times in order to mix the clot activator with the blood. The blood was then allowed to clot for 30 min before centrifugation (CM6MT, ELMI Ltd, Riga, Latvia) at room temperature for 10 min at 2000 rev/min for separation of the serum. A 4 mL anticoagulant tube (367861, BD Diagnostics Ltd, Oxford, UK) containing K_2 ethylenediaminetetraacetic acid was also filled and then inverted eight times. WBC was measured in whole blood from the anticoagulant tube using an automated hematology analyser (Micros, Horiba ABX SAS, Montpellier, France). The blood was then centrifuged using the previously described procedure in order to separate the plasma. For storage, 2 mL safe-lock tubes (120094, Eppendorf UK Ltd, Stevenage, UK) were pipetted with

300 μL of extracted serum and 300 μL of extracted plasma and frozen at –80°C.

After thawing, serum TC and high-density lipoprotein cholesterol (HDL-C) were measured using an automated chemistry analyser (RX Monza, Randox Laboratories Ltd, Crumlin, UK). CRP was measured in plasma using a sandwich enzyme-linked immunosorbent assay (ELISA; EL10022, Bio Supply Ltd, Bradford, UK) and plasma IL-6 was measured using a high-sensitivity sandwich ELISA (HS600B, R&D Systems Europe Ltd, Abingdon, UK). The manufacturer's instructions were followed for the assay kits. Briefly, after preparation of the CRP standards, wash buffer, conjugate, and substrate solution, the pre-coated 96 well antibody microtiter plate wells were filled with 100 μL of either standard or sample. The plate was tapped gently to mix the contents of the wells and then covered and left for incubation for 30 min at 37°C. The well contents were then decanted and washed with the wash buffer five times. Conjugate (100 μL) was added into the wells and the plate was left to incubate for a further 30 min. The wash procedure was repeated. The wells were then filled with 100 μL of substrate solution and left for a final 15 min incubation. Stop solution (100 μL) was added into the wells. A standard linear curve for determination of CRP was generated by reading the optical density of the wells at 450 nm using a microtiter plate reader (ELX800, BioTek Instruments Inc, Winooski, VT, USA). IL-6 was measured in a similar fashion. Briefly, 100 μL of diluent was added into the wells, followed by 100 μL of either standard or sample. Incubation was for 2 h at room temperature on a horizontal microtiter plate shaker set at 250 rev/min. After decanting the well contents, the wash buffer was used six times. Conjugate (200 μL) was then added into the wells and the plate was again left for incubation. Following another washing step, 50 μL of substrate solution was added into the wells. A 1 h incubation (without the shaker) followed. Then 50 μL of amplifier solution was added into the wells, followed by a final incubation of 30 min, again without the shaker. Stop solution (50 μL) was added into the wells prior to reading the optical density at 490 nm. IL-6 was determined by generating a four parameter logistic curve.

All blood measurements were obtained in duplicate and mean values were used for data analysis. The coefficient of variation for measurement of

WBC was < 2.5%. The intra- and inter-assay coefficients of variation for measurement of CRP, IL-6, TC, and HDL-C were < 6.9, 9.6, 4.6, and 3.1%, respectively. The minimal level of detection for WBC, CRP, IL-6, TC, and HDL-C was 0.50 10^9 cell/L, 0.03 mg/L, 0.04 pg/mL, 0.35 mmol/L, and 0.19 mmol/L, respectively.

A graded treadmill exercise test, as described previously,[78] was performed for determination of VO_{2max} and HR_{max}. Briefly, following a 3 min warm-up of level walking at 2.7 km/h, the Bruce protocol was used until volitional exhaustion with HR measured via short-range radio telemetry (RS400, Polar Electro Oy, Kempele, Finland) and breath-by-breath pulmonary gas exchange data collected using an indirect calorimeter (Oxycon Pro, Viasys Healthcare GmbH, Hoechberg, Germany).

The participants were then familiarised with the instruments for the study and instructed on their proper usage. The questionnaire for mood[122] was administered, followed by the questionnaire for HRQoL.[123] Instructions were given to all participants to maintain their habitual diet and refrain from engagement in other exercise for the duration of the study period.

A triaxial accelerometer (wGT3X+ 2.0, ActiGraph LLC, Pensacola, FL, USA) with accompanying HR monitor was worn by the dancers (a complete description of which is presented in Section 3.3) during Zumba fitness. The utility of this equipment for dance has been described in detail elsewhere.[78]

Mood was measured via the six factor Profile of Mood States 2nd Edition Short Form for Adults (POMS-2).[122] The selected time frame wording was "past week, including today". The questionnaire uses a Likert-type scale ranging from zero (not at all) to four (extremely). Cronbach coefficient alphas have been reported of 0.86, 0.84, 0.88, 0.87, 0.84, and 0.83 for anger-hostility, confusion-bewilderment, depression-dejection, fatigue-inertia, tension-anxiety, and vigour-activity, respectively. Standardised results from the publisher's web-based scoring database (mhsassessments.com) were used for data analysis.

Measurement of HRQoL was undertaken using the eight factor RAND 36-Item Health Survey 1.0 (SF-36).[123] The questionnaire contains the same questions as those found in the Medical Outcomes Study 36-Item Short-Form Health Survey,[167] but is available from the publisher without license. Cronbach coefficient alphas have been reported of 0.93, 0.84, 0.78, 0.78, 0.86, 0.85, 0.83,

and 0.90 for physical functioning, role limitations due to physical health, pain, general health, energy/fatigue, social functioning, role limitations due to emotional problems, and emotional well-being, respectively.

Participants in the intervention group took part in twelve classes of Zumba fitness over an 8 wk period. A frequency of one weekly class was attended during the first half of the intervention, followed by a progression to two weekly classes during the second. Attendance in two weekly sessions of Zumba fitness has been demonstrated[79] to meet the WHO recommendation[12] for vigorous aerobic PA necessary for the maintenance of health. Accelerometry and HR data were collected during all sessions. The instructor-led group classes were taught by certified Zumba fitness teachers in established venues in the Royal Borough of Kingston and the surrounding communities of London, UK. All teachers were current members of the Zumba Instructor Network (zumba.com). Each class was 1 h in length and a recovery period of at least 48 h was taken between classes. Instructions were given to perform euhydrated and at least 2 h postprandial. The Zumba fitness venues and scheduling of sessions were self-selected by the participants and were chosen to be representative of where and when they might normally attend classes of aerobic dance for exercise purposes. The content of a typical Zumba fitness class has been described previously.[79] Participants in the control group maintained their habitual activity for the duration of the study period.

All participants underwent the pre- and post-intervention laboratory assessments and completed the psychological evaluations at wk 0, 8, and 16. The follow-up questionnaires were delivered to and collected from the participants via mail.

Calculations of total EE, total SC, HRR, and MET during Zumba fitness were undertaken using the mean of the data collected during the dance classes. HRR was formulated using previously described methods,[79] and the combined accelerometry and HR data were processed with a previously described dance-specific cut-point and prediction equation technique.[77]

All statistical analyses were conducted using the programming language R (R 3.0, The R Foundation for Statistical Computing, Vienna, Austria). Differences between groups in pre-intervention anthropometric, physiological, and inflammatory measures and pre-intervention mood and HRQoL factors

were ascertained using independent *t*-tests. Pre- and post-intervention differences in anthropometric and physiological measures were explored using dependent *t*-tests. Inflammatory biomarkers were assessed pre- and post-intervention using RM-ANCOVA with VO_{2max} and BF selected as covariates.[169] RM-ANCOVA was also used to determine differences across time in mood and HRQoL factors; the pre-intervention score was selected as the covariate in the models. Relationships between anthropometric, physiological, and inflammatory measures and mood and HRQoL factors were investigated with Pearson's correlation coefficients. Alpha was set at 0.05 and Bonferroni corrections were made for pairwise comparisons. Centrality and spread are presented as mean ± standard deviation with 95% CI reported where appropriate.

7.4. Results

Missing data

Two intervention participants missed a single Zumba fitness session each; the average rate of attendance for this study was therefore 98%. Blood draw by venipuncture was unsuccessful in three intervention and five control participants due to either the maximum number of attempts (two) permitted in our laboratory for research purposes being reached, or consent for venipuncture being withdrawn. These participants were therefore excluded from the data analysis of cholesterol and inflammatory biomarkers.

Pre-intervention anthropometric, physiological, and inflammatory measures

Results of the between-group comparison of anthropometric, physiological, and inflammatory measures taken at pre-intervention are presented (Table 7.1).

Responses during Zumba fitness

The Zumba fitness sessions elicited an exercise intensity of 6.73 ± 0.24 MET and a HRR of 51.1 ± 15.6%. It was revealed that total EE and total SC were 410 ± 70 kcal and 6681 ± 674 step, respectively, during the 1 h classes.

Pre- to post-intervention changes in anthropometric, physiological, and inflammatory measures

Results of the pre- to post-intervention assessment of changes in anthropometric, physiological, and inflammatory measures are presented (Table 7.2).

Table 7.1. Between-group comparison of anthropometric, physiological, and inflammatory measures prior to 8 wk of engagement in Zumba fitness (intervention group; *n* = 10) or maintenance of habitual activity (control group; *n* = 10) in a community-recruited cohort of overweight and physically inactive women.

	Total	Intervention	Control	*p*
Anthropometric				
Age (yr)	34 ± 12	33 ± 11	35 ± 13	0.80
BM (kg)	70.6 ± 5.9	69.9 ± 4.9	71.4 ± 7.0	0.59
BF (%)	31.3 ± 5.5	30.9 ± 5.5	31.7 ± 5.8	0.76
BMI (kg/m^2)	27.1 ± 1.9	26.7 ± 1.7	27.6 ± 2.0	0.30
Physiological				
VO_{2max} (mL/kg/min)	28.7 ± 6.2	29.4 ± 5.9	28.0 ± 6.7	0.61
Mean arterial BP (mmHg)	90 ± 8	89 ± 8	91 ± 9	0.71
TC to HDL-C ratio	4.1 ± 1.5	4.2 ± 1.2	4.0 ± 1.8	0.89
Inflammatory				
CRP (mg/L)	1.5 ± 0.8	1.2 ± 1.0	1.7 ± 0.5	0.26
IL-6 (pg/mL)	1.2 ± 0.4	1.1 ± 0.5	1.3 ± 0.3	0.64
WBC (10^9 cell/L)	6.3 ± 1.7	6.7 ± 1.8	5.8 ± 1.4	0.36

Data are presented as mean ± standard deviation; BF = percent body fat; BM = body mass; BMI = body mass index; BP = blood pressure; CRP = C-reactive protein; HDL-C = high-density lipoprotein cholesterol; IL-6 = interleukin-6; TC = total cholesterol; VO_{2max} = maximal oxygen uptake; WBC = white blood cell count.

Table 7.2. Comparison of pre- to post-intervention changes in anthropometric, physiological, and inflammatory measures following 8 wk of engagement in Zumba fitness (intervention group; *n* = 10) or maintenance of habitual activity (control group; *n* = 10) in a community-recruited cohort of overweight and physically inactive women.

	Intervention			Control		
	Change	95% CI	*p*	Change	95% CI	*p*
Anthropometric						
BM (kg)	–0.5	–1.4 to 0.4	0.23	–0.1	–0.4 to 0.1	0.27
BF (%)	–1.2	–2.3 to –0.0	< 0.05 *	0.1	–0.5 to 0.6	0.88
BMI (kg/m^2)	–0.2	–0.5 to 0.1	0.22	–0.1	–0.2 to 0.0	0.28
Physiological						
VO_{2max} (mL/kg/min)	3.1	1.0 to 5.1	< 0.01 *	–0.7	–2.0 to 0.5	0.20
Mean arterial BP (mmHg)	–1	–5 to 7	0.71	0	–4 to 3	0.83
TC to HDL-C ratio	0.3	–1.5 to 2.0	0.72	–0.1	–3.1 to 2.8	0.92
Inflammatory						
CRP (mg/L)	–0.5	–1.0 to 0.0	0.05	0.1	–1.0 to 1.3	0.81
IL-6 (pg/mL)	–0.4	–0.8 to –0.1	< 0.05 *	0.1	–0.6 to 0.4	0.64
WBC (10^9 cell/L)	–2.1	–3.5 to –0.7	< 0.05 *	–0.5	–1.5 to 0.6	0.27

BF = percent body fat; BM = body mass; BMI = body mass index; BP = blood pressure; CI = confidence interval; CRP = C-reactive protein; HDL-C = high-density lipoprotein cholesterol; IL-6 = interleukin-6; TC = total cholesterol; VO_{2max} = maximal oxygen uptake; WBC = white blood cell count; * significantly different from pre- to post-intervention.

Psychological evaluation

No pre-intervention differences (all $p > 0.05$) were observed between groups in the mood and HRQoL factors assessed. Results of the comparison of mood scores across time are presented (Table 7.3). In the intervention group, a significant main effect of time was obtained for fatigue-inertia ($p < 0.001$; partial $\eta^2 = 0.69$) and vigour-activity ($p < 0.05$; partial $\eta^2 = 0.37$). Post hoc analyses revealed a significant improvement ($p < 0.05$) in both fatigue-inertia and vigour-activity at post-intervention in comparison with pre-intervention and follow-up. The average post-intervention decrease in fatigue-inertia was 9.2 when compared with the pre-intervention score; however, fatigue-inertia increased by an average of 7.4 when the follow-up questionnaire was administered. Similarly, vigour-activity increased by an average of 8.2 at post-intervention when compared with the pre-intervention score. The value at follow-up, however, decreased by an average of 5.6. No other differences (all $p > 0.05$) in mood were observed. Results of the comparison of HRQoL scores across time are presented (Table 7.4). A significant main effect of time was obtained for physical functioning ($p < 0.01$; partial $\eta^2 = 0.57$), general health ($p < 0.01$; partial $\eta^2 = 0.60$), energy/fatigue ($p < 0.01$; partial $\eta^2 = 0.55$), and emotional well-being ($p < 0.001$; partial $\eta^2 = 0.63$) for intervention participants. Post hoc tests indicated a significant improvement ($p < 0.05$) in all four of the aforementioned factors at post-intervention in comparison with pre-intervention and follow-up. Physical functioning increased by an average of 8.6 at post-intervention when compared with the pre-intervention score, but decreased by an average of 7.0 at follow-up. General health, in a similar fashion, increased by an average of 9.6 at post-intervention when compared to pre-intervention. The general health score decreased, however, by an average of 9.1 at follow-up. Furthermore, there was an average post-intervention increase in energy/fatigue of 15.5 when compared with the pre-intervention score; however, energy/fatigue decreased by an average of 13.5 at the time of follow-up. Emotional well-being also increased at post-intervention, when compared to pre-intervention, by an average of 9.2; however, at follow-up the score decreased by an average of 7.8. No other differences (all $p > 0.05$) in HRQoL were found.

Table 7.3. Comparison across time of mood factors assessed using the POMS-2 during 8 wk of engagement in Zumba fitness (intervention group; *n* = 10) or maintenance of habitual activity (control group; *n* = 10) in a community-recruited cohort of overweight and physically inactive women.

	Pre-intervention	Post-intervention	Follow-up
Anger-hostility			
Intervention	47.6 ± 9.2	43.3 ± 8.6	46.6 ± 8.2
Control	46.9 ± 7.2	47.1 ± 6.8	47.2 ± 7.1
Confusion-bewilderment			
Intervention	46.0 ± 7.6	43.6 ± 6.4	44.0 ± 7.1
Control	48.6 ± 8.6	48.7 ± 7.5	49.4 ± 9.4
Depression-dejection			
Intervention	50.3 ± 9.3	46.2 ± 6.5	48.2 ± 8.2
Control	46.9 ± 6.4	47.4 ± 6.2	47.9 ± 7.4
Fatigue-inertia			
Intervention	49.8 ± 13.5	40.6 ± 10.7 *	48.0 ± 11.2
Control	46.9 ± 10.1	45.7 ± 11.3	48.2 ± 12.4
Tension-anxiety			
Intervention	45.9 ± 9.9	42.8 ± 8.1	44.1 ± 9.5
Control	48.0 ± 8.8	47.7 ± 10.9	50.4 ± 9.4
Vigour-activity			
Intervention	49.5 ± 11.3	57.7 ± 10.1 *	52.1 ± 9.8
Control	47.0 ± 12.4	48.2 ± 13.3	46.0 ± 10.6

Data are presented as mean ± standard deviation; POMS-2 = Profile of Mood States 2nd Edition Short Form for Adults; * significantly different from pre-intervention and follow-up at $p < 0.05$.

Table 7.4. Comparison across time of HRQoL factors assessed using the SF-36 during 8 wk of engagement in Zumba fitness (intervention group; *n* = 10) or maintenance of habitual activity (control group; *n* = 10) in a community-recruited cohort of overweight and physically inactive women.

	Pre-intervention	Post-intervention	Follow-up
Physical functioning			
Intervention	87.0 ± 13.9	95.6 ± 11.7 *	88.5 ± 14.3
Control	84.9 ± 15.6	82.4 ± 16.9	84.0 ± 17.4
Role limitations due to physical health			
Intervention	91.1 ± 17.5	92.5 ± 16.9	89.5 ± 18.7
Control	91.6 ± 16.7	94.1 ± 15.8	92.2 ± 14.8
Pain			
Intervention	90.8 ± 14.3	89.5 ± 13.4	88.8 ± 14.3
Control	88.9 ± 17.9	85.5 ± 18.6	87.2 ± 17.5
General health			
Intervention	68.5 ± 15.7	78.1 ± 13.4 *	69.0 ± 17.5
Control	66.4 ± 17.8	62.5 ± 17.3	63.1 ± 19.6
Energy/fatigue			
Intervention	62.5 ± 15.5	78.0 ± 14.8 *	64.5 ± 13.4
Control	63.5 ± 14.4	64.0 ± 13.7	60.5 ± 15.7
Social functioning			
Intervention	90.0 ± 13.9	89.1 ± 15.5	87.7 ± 14.4
Control	87.5 ± 16.4	84.5 ± 19.2	85.9 ± 17.6
Role limitations due to emotional problems			
Intervention	83.3 ± 16.3	87.3 ± 15.1	84.7 ± 16.2
Control	83.9 ± 18.7	82.4 ± 19.3	79.9 ± 17.6
Emotional well-being			
Intervention	77.2 ± 13.7	86.4 ± 11.6 *	78.6 ± 10.4
Control	76.2 ± 14.6	76.6 ± 11.1	74.8 ± 12.8

Data are presented as mean ± standard deviation; HRQoL = health-related quality of life; SF-36 = RAND 36-Item Health Survey 1.0; * significantly different from pre-intervention and follow-up at $p < 0.05$

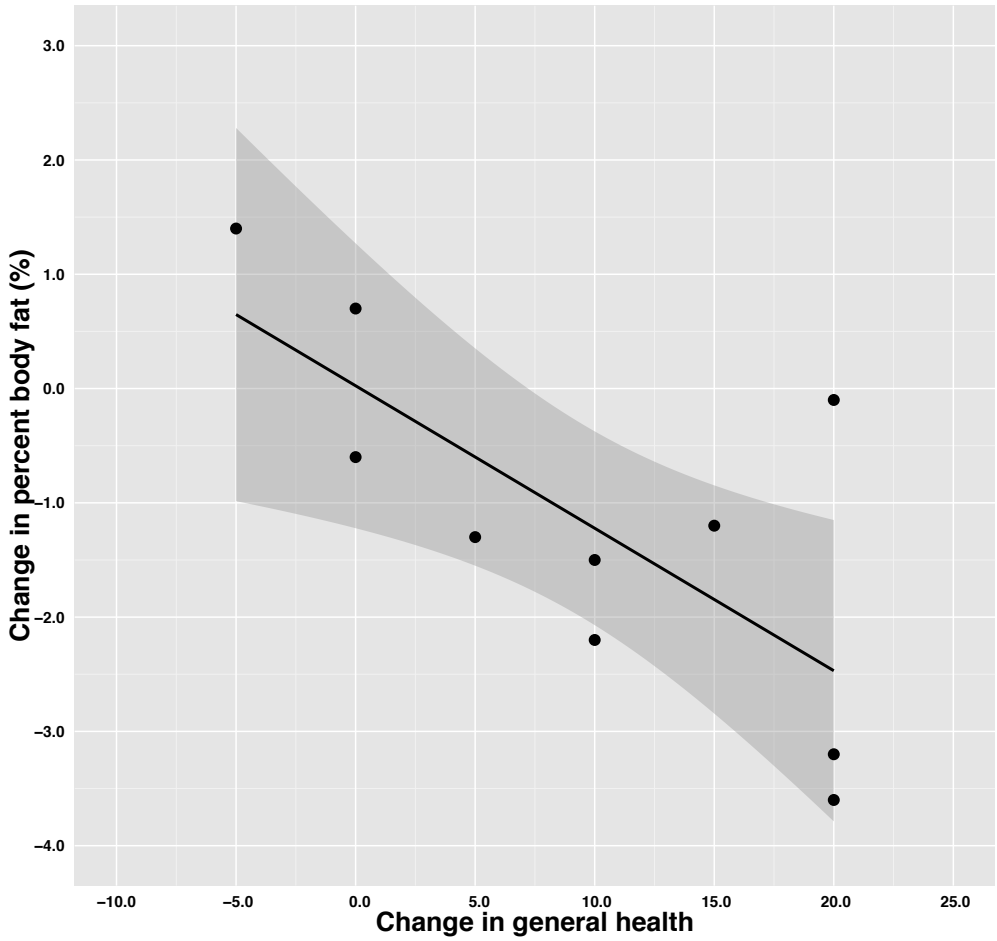

Figure 7.1. Significant negative relationship (r = –0.73, p < 0.05) between pre- to post-intervention changes in percent body fat and the health-related quality of life general health factor in the intervention group (n = 10). Pearson's correlation with 95% confidence intervals are shown.

Correlation between anthropometric, physiological, and inflammatory measures and mood and HRQoL factors

Results of the correlation analyses between pre- to post-intervention changes in the HRQoL general health factor and BF and VO_{2max} in the intervention group are presented (Figures 7.1 and 7.2, respectively). No other associations (all $p > 0.05$) between the anthropometric, physiological, and inflammatory measures and mood and HRQoL factors were revealed in either the intervention or control group.

7.5. Discussion

Attendance in one to two 1 h classes of Zumba fitness over an 8 wk period modestly improved VO_{2max}, body composition, and inflammatory

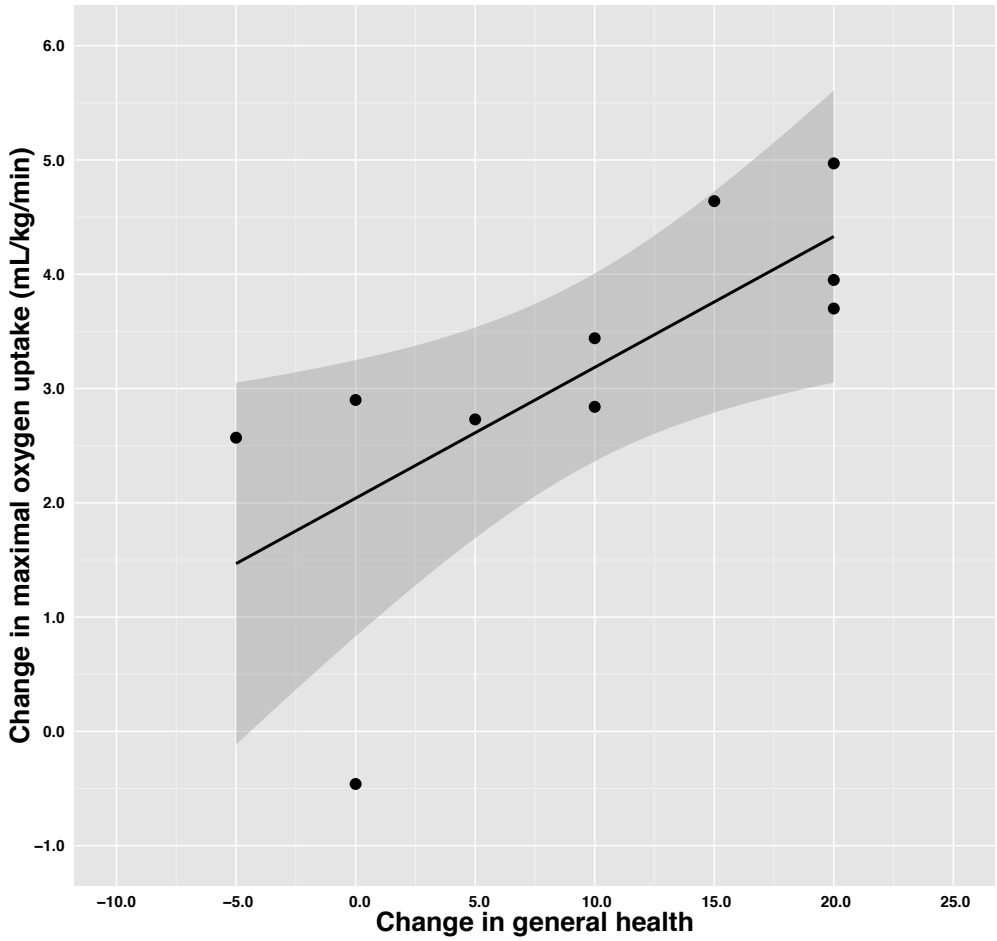

Figure 7.2. Significant relationship (r = 0.71, p < 0.05) between pre- to post-intervention changes in maximal oxygen uptake and the health-related quality of life general health factor in the intervention group (n = 10). Pearson's correlation with 95% confidence intervals are shown.

biomarkers relevant to cardiovascular health in overweight and physically inactive women with little or no previous experience in Latin-themed aerobic dance. Large magnitude[162] pre- to post-intervention enhancements were observed in factors of both mood (fatigue-inertia and vigour-activity) and HRQoL (physical functioning, general health, energy/fatigue, and emotional well-being). No differences were found in any of the evaluated outcomes for control participants. Hence, the current work demonstrates that a community-recruited cohort of individuals undertaking dance-related PA in a naturalistic setting can indeed improve measures of both physical and mental health. The relevance of these findings, in terms of gaining a holistic understanding of the efficacy of this particular activity, should not be underestimated considering

the current,[29] and likely growing, popularity of Zumba fitness in both Latin and non-Latin communities.

The physiological demand of the Zumba fitness classes, when expressed as an average MET value across the intervention, was higher in the current work in comparison to our previous finding.[79] This discrepancy is likely due to the current participants having a higher BMI and lower VO_{2max} than those previously recruited. As the MET value of PA is a measure of EE relative to BM (where 1 MET = 1 kcal/kg/h of energy expended), it is plausible that adults taking part in aerobic dance who are overweight or obese might, on the whole, have a higher MET value during participation than their normal weight counterparts. Moreover, as the current participants had a lower VO_{2max}, it is possible that the relative intensity of Zumba fitness experienced was higher than in those who took part in our earlier work. It is known that the physiological responses to aerobic dance are affected by several factors,[92] including cardiorespiratory fitness, such that those with a low VO_{2max} work at a higher relative intensity than those with a high VO_{2max}. The presented results, along with our previous findings,[79] and when considering the work of others where adults of both sexes and different cardiorespiratory fitness levels, ages, and previous experience in Zumba fitness were recruited,[88,89] taken together, support the notion that Zumba fitness is best categorised as a vigorous, not a moderate, intensity activity. This may explain why Zumba fitness participants demonstrate a higher prevalence of class-related injuries with increasing class frequency (beyond three sessions weekly), even after adjustment for age, sex, and previous experience.[29] Of note, a recent 16 wk investigation of Zumba fitness indicated that of the thirteen participants that did not complete the intervention, ten cited the strenuousness of the activity or having experienced class-related injury/pain as reason for withdrawal from the research; the volume of classes used was three sessions weekly.[86] It may therefore be prudent for future researchers of Zumba fitness to consider utilising a progressive approach in terms of weekly volume, as was employed in the present study, when evaluating this particular form of aerobic dance.

It was reported that vigorous intensity PA increased following a six month Latin-themed aerobic dance intervention.[71] Minutes of PA were self-reported via questionnaire. Lee and colleagues,[72] on the other hand, used both

subjective and objective techniques and also reported increased PA of a moderate intensity following a 4 wk Latin dance intervention. In a recent 12 wk investigation of Latin dance, again using simultaneous subjective and objective methods for the assessment of PA, it was reported that questionnaire results indicated increased total PA minutes post-intervention; however, no increase was revealed when PA was evaluated using accelerometry.[18] This discrepancy not only confounds the issue of whether Latin dance interventions are efficacious in terms of increasing dance-related PA, but also highlights the need for using activity-specific accelerometer data processing techniques. The conversion of accelerometer counts in the research of Marquez and colleagues[18] was undertaken using cut-points value calibrated on a treadmill. This method has now been shown to be invalid for the processing of accelerometer data collected during dance[77] and may explain the reported discrepancy between the two aforementioned outcome measures.

Forty weeks of Zumba fitness attended two to three times weekly increased VO_{2max} and decreased BF by 2.2 mL/kg/min and –1.3%, respectively.[75] These improvements are similar to the results presented in the current research, despite weekly volume of classes and total intervention length being greater in the work of Barene and colleagues.[75] A larger increase in VO_{2max} (~5 mL/kg/min) and smaller decrease in BF (~–0.6%) were observed consequent to six months of Latin-themed aerobic dance undertaken three times weekly[71] and 4 wk of Latin dance undertaken twice weekly,[72] respectively. These interventions, along with the current work, were conducted using primarily community-recruited female participants. We would argue that this is a reasonable representation of individuals who actually attend instructor-led group classes of aerobic dance under real (i.e., non-research-related) conditions.[167] In the present study, we demonstrated only modest improvements in VO_{2max} and body composition, with no concomitant change in BMI. Whether dance-related PA programmes are effective[75,86] or ineffective[71,76] for lowering BMI in community-based adult cohorts remains an unresolved issue in the literature. Regardless, improved VO_{2max} and body composition through regular PA engagement has been associated with enhanced health outcomes and decreased cardiovascular risk factors in adults, irrespective of weight loss.[170]

Although the current work is the only research we are aware of that has investigated inflammatory responses to Latin-themed aerobic dance, King and colleagues[45] demonstrated association between aerobic dance participation and reduced likelihood of inflammatory biomarker elevation. Specifically, after adjustment for age, sex, race, BMI, and smoking and health status, odds ratios for CRP and WBC were 0.31 [95% CI 0.13 to 0.78] and 0.11 [95% CI 0.03 to 0.41], respectively, for adults taking part in twelve or more classes monthly when compared to engagement in eleven classes or less. It was suggested by the investigators that participation in aerobic dance may be more beneficial in terms of moderating inflammatory biomarkers relevant to cardiovascular health than other types of PA; however, when interpreting these findings it needs to be considered that objective measures of PA, including intensity and time parameters, which we would argue are necessary for a comprehensive comparison of different PA types, were not collected in this study. Okita and colleagues[50] examined participants before and after two months of engagement in supervised PA involving twice weekly sessions of aerobic dance combined with traditional aerobic exercise. The weekly volume of PA (~4 h) was substantially higher than the volume used in the current research. CRP decreased to a similar degree as that reported in the present study (35 versus 42%), whilst WBC was also reduced, although to a smaller degree than that observed in this investigation (8 versus 31%). In a study comparing different PA domains,[171] it was demonstrated that participation in increasing intensities of leisure (but not specifically dance-related) PA was negatively correlated with IL-6. However, in the same study it was also shown that no relationship existed between leisure PA and CRP after adjustment for all potential confounding factors. Further highlighting the inconsistencies in the literature, LeCheminant and colleagues[49] collected objective PA data and reported that accelerometer counts were negatively correlated ($p < 0.05$) with CRP. When adjusted for BMI, the relationship weakened ($p = 0.08$), and when adjusted for BF (a measure not recorded in any of the aforementioned studies of inflammatory status), total PA no longer predicted ($p = 0.73$) CRP. It is possible that the discrepancies in the literature in regards to the likely anti-inflammatory properties of regular PA may be explained by BF, which has been suggested to be a more sensitive measure than BMI when accounting for

potential confounding factors related to PA and inflammatory status.[49] Indeed, in a review evaluating 40 observational and 12 randomised controlled studies, the roles of both BF and cardiorespiratory fitness were assessed in the context of PA and its relationship with inflammatory biomarkers.[169] It was suggested that BF, cardiorespiratory fitness, and inflammatory biomarkers may be associated in such a way that i) the inflammatory biomarker and cardiorespiratory fitness relationship could either be confounded or mediated by BF, or, that ii) cardiorespiratory fitness and BF might possibly share the same causal pathways. Despite the inconclusive evidence, we would suggest that PA specialists ought to promote the importance of improving both cardiorespiratory fitness and body composition in adults through increased regular PA.

This study is also the only investigation we are aware of that has evaluated change over time in mood consequent to engagement in Latin-themed aerobic dance. Acute mood change following a single 1 h session of aerobic dance was assessed using the Profile of Mood States questionnaire.[61] Although the participants in this research varied in their previous experience of aerobic dance (ranging from less than one month to > 1 yr of classes attended), post-dance scores revealed small magnitude improvements in anger and vigour, alongside moderate to large magnitude improvements in confusion, depression, and tension. In the current work, enhancements of a large magnitude were reported in fatigue-inertia and vigour-activity only, indicating that the intervention participants were feeling less worn out, weary, and drained, and more lively, energetic, and enthusiastic as a result of participation in Zumba fitness. Although our results are dissimilar to those previously reported, we would argue that mood benefits stemming from engagement in aerobic dance might not necessarily be expected to be the same when comparing acute change following a single session with changes after an 8 wk period. Also, the study of McInman and Berger[61] assessed individuals with previous experience in aerobic dance and of a younger age than those recruited in the current research. Additionally, cardiorespiratory fitness data were not provided, potentially further hindering the comparison between the two studies. Despite these differences, we would argue that the favourable results reported,[61] along with our own findings, suggest that aerobic dance participation does indeed

have the potential for mood enhancement. This is consistent with previous investigations indicating that exercise in general can be effective for mood regulation, particularly in clinical cohorts[63] and those experiencing a depressed mood state pre-exercise.[62]

Higher levels of PA have been associated with better HRQoL in adults[69]; however, the current work is the only research we are aware of to have specifically tested the hypothesis that dance affects HRQoL, as measured by the SF-36, in a positive fashion. In an 8 wk Zumba fitness intervention,[67] change in quality of life was determined using the WHO Quality of Life questionnaire. It was demonstrated that those assigned to classes of Zumba fitness twice weekly improved their quality of life score post-intervention with a large magnitude effect (partial $\eta^2 = 0.45$). In the current study, four of the eight factors of the SF-36 resulted in improved values post-intervention; the average effect was similar in magnitude (partial $\eta^2 = 0.59$) to that reported by Donath and colleagues.[67] As the Zumba fitness classes in the current research were group-based, it is possible that engagement may have fostered feelings of social connectedness among the participants.[172] Consequently, a sense of camaraderie may have been experienced, which we would argue would likely be assistive in terms of exercise adherence.[7] However, as our follow-up measures were no different to those at pre-intervention, it is also possible that the weekly volume of classes or total intervention length were not sufficient to facilitate development of the social bonds necessary for maintenance of the activity after the intervention period. Moreover, we would argue that musical accompaniment is central to most, if not all, genres of dance, including aerobic dance. In a recent review,[172] the biological mechanisms underlying the proposed social bonding effect of music during synchronised group-based rhythmic activities were described. It is possible that some of these factors may have contributed to the improved HRQoL observed in the current work. Interestingly, we also found associations between change in the HRQoL general health factor and change in both BF and VO_{2max}. As Zumba fitness is a vigorous intensity activity (as discussed earlier), and taking into account the fact that the participants were physically inactive and of moderately low cardiorespiratory fitness, it is plausible to assume that our intervention provided sufficient stimulus to simultaneously impart both physiological and

psychological gains. Sports and exercise (i.e., swimming, running, cycling, gym-based exercise, and team sports), and walking, as PA types, have been previously correlated with modest effects on HRQoL.[69] The current work adds to the literature by demonstrating that Latin-themed aerobic dance is related to enhanced feelings of general health when VO_{2max} and body composition are improved. Although the biological mechanisms to explain this are complex and remain unclear, it is probable that promotion of a reduced anti-inflammatory state, optimisation of neuroendocrine and physiological stress response systems, and/or enrichment of neuroplasticity and growth factor expression are involved.[173] These may be contributing factors in terms of the beneficial effects of regular PA consistently reported in adults.[12]

The current investigation has several strengths worth noting. These include the recruitment of an ecologically valid sample of participants (which is in contrast to previous assessments of Zumba fitness[88]), the use of objectively measured PA and dance-specific accelerometer data processing techniques (again, in contrast to previous Zumba fitness studies[76]), and the use of a naturalistic (i.e., self-selected) environment in which the dance-related data collection was undertaken (also in contrast to previous PA interventions utilising Zumba fitness[86]). There are also some limitations that warrant highlighting. Firstly, as no laboratory-based measurements were taken at follow-up, we cannot discern the time course over which the enhancements in VO_{2max}, body composition, and inflammatory biomarkers lasted. Secondly, we cannot rule out selection bias in this study in terms of participant preference for Latin music and/or dance. There is indeed a possibility that the individuals who enrolled in this research were already aware that they enjoyed listening to Latin music or even being involved in dance outside of an exercise context (i.e., social gatherings). Thirdly, as the psychological measures at follow-up were no different to pre-intervention levels, it is likely that the Zumba fitness participants no longer continued to attend classes after the research sessions were over. This may indicate a limited applicability of PA interventions utilising this particular form of aerobic dance and could, although speculatively, be related to the costs involved of attending classes regularly.

Using a randomised controlled study design, we demonstrated that Zumba fitness is beneficial, physiologically, for improving cardiovascular risk

factors and inflammatory biomarkers, and psychologically, for enhancing factors of mood and HRQoL in a cohort of overweight and physically inactive women. When interpreted in a community-based PA and psychosocial health promotion context, our data suggest that Zumba fitness is indeed an efficacious health-enhancing activity for adults.

8 GENERAL DISCUSSION

8.1. Thesis summary

The current research involved development of a novel activity-specific physiological measurement method for assessment of dance using a body-worn monitoring system for recording of HR and high resolution triaxial accelerometry signals. Under laboratory-based conditions, accelerometer value calibration, cross-validation, and reliability analyses were performed with ActiGraph monitors and a HR telemetry system. The technique was then used in ecologically valid environments to evaluate Latin dance and Latin-themed aerobic dance for their health-enhancing properties in experienced dancers and non-exercisers. Differences in physiological measures were determined between women and men and between classes of salsa dance and Zumba fitness. Psychological measures associated with engagement in dance were captured using previously validated questionnaires. These data were assessed quantitatively. Correlations between physical and mental health measures were explored. As results indicated that Zumba fitness is a more physiologically demanding activity when compared with salsa dance, but equal in terms of acute change in affective responses, classes of Zumba fitness were then selected for use in a randomised controlled study. Community-recruited overweight and physically inactive individuals, a group commonly targeted in PA and psychosocial health promotion strategies, were enrolled in the research to examine the efficacy of Latin dance as a health-enhancing leisure activity in non-clinical adults.

Generating original research to assist exercise scientists and health promotion practitioners in assessing this non-traditional form of aerobic PA is warranted as the popularity of Latin dance and Latin-themed aerobic dance continues to grow[29,30] in both Latin and non-Latin communities. This genre of dance has been utilised as an expressive and creative medium for PA

promotion not only in cohorts of non-clinical adults,[77,78,79] but also in older adult[18] and underserved[71] populations, and in individuals with anxiety- or stress-related symptoms,[21] depression,[27] obesity,[76] type two diabetes,[22] and dementia.[20] The importance of having valid and reliable measures of dance for health promotion purposes is demonstrated by the manuscript for Study 1 having been accepted (personal communication with Dr. Stephen Herrmann of Augustana College, Sioux Falls, SD, USA; March 2014) for inclusion in the next version of the Compendium of Physical Activities.[174] This database has received widespread acceptance over the past two decades as a reference source for the classification and quantification of human EE during PA. The Compendium of Physical Activities is commonly cited in PA surveillance, epidemiological, intervention, and clinical research and is also used for the writing of PA guidelines.[174] No entries currently exist (1993, 2000, or 2011 versions) to characterise the metabolic cost of either salsa dance or Zumba fitness.

8.2. Dance-related physiological and psychological responses

The dance-based intervention failed to demonstrate improvements in several of the evaluated metabolic risk factors for non-communicable disease. Specifically, BP and cholesterol did not improve following 8 wk of Zumba fitness. Although the BP lowering effect of aerobic exercise has long been established, long-term reductions have been shown to be more modest than acute changes observed immediately following exercise.[175] Moreover, overweight and physically inactive pre-hypertensive individuals demonstrate greater BP reductions consequent to aerobic exercise when compared with their normotensive counterparts.[176] Accordingly, this may explain the reduction in BP following dance participation reported by Araneta and Tanori[76] (pre-intervention systolic BP = 131 mmHg), which is in contrast to the current findings and the results of Barene and colleagues[75] (pre-intervention systolic BP = 113 mmHg), where no changes were observed. In a 10 wk (non-dance-related) aerobic exercise study, a 6% reduction in BP was observed in normotensive overweight and obese women.[177] In this investigation, the weekly volume of PA was greater than that used in our own work, which may explain the observed improvement in post-intervention BP, despite a lower pre-intervention value. Intriguingly, the 2013 American Heart Association

scientific statement[178] evaluating alternative approaches to BP lowering concluded that of the methods reviewed, the strongest evidence available was in support of aerobic (and dynamic resistance) exercise for the adjunct treatment of elevated BP in pre-hypertensive and hypertensive individuals. Mechanistically, it is probable that the hypotensive effect of regular aerobic exercise in adults is due, at least in part, to a reduction in systemic vascular resistance, whereby the sympathetic nervous and renin-angiotensin systems likely play a role.[179] Other factors, including improved endothelium-dependent vasodilation and arterial compliance are also likely involved and modulated through exercise.[178]

Although no improvement in cholesterol was reported following engagement in three Latin-themed aerobic dance interventions,[75,76,86] aerobic exercise in general has been shown to indeed be effective for decreasing TC and increasing HDL-C in women.[180,181] Associations have also been observed between decreased TC and BF and increased HDL-C and VO_{2max}[180]; however, it remains unclear whether the improved cholesterol is a result of the exercise itself or whether the concomitant enhancements in body composition and cardiorespiratory fitness are moderators of the relationship.[180] Regardless, it has been shown that aerobic PA yields improvements of 2 to 5% in blood lipids and lipoproteins in female exercisers[180] when undertaken following the WHO-recommended[3] PA frequency, intensity, and time guidelines. It has also been shown that participation in two 1 h classes of Latin-themed aerobic dance weekly meets this PA recommendation.[89] Mathunjwa and colleagues[177] reported 2 and 5% reductions in TC to HDL-C ratio attributable to 5 and 10 wk, respectively, of aerobic dance. These results contrast that of our own, where no post-intervention improvement in TC to HDL-C ratio was observed following 8 wk of aerobic dance. It should be noted, however, that random assignment, a non-exercise control group, and analysis of dietary intake were not utilised in the research of Mathunjwa and colleagues,[177] thus, generalisability of these results may be limited.

Elevated inflammatory biomarkers have been associated with physical (as outlined in Sections 2.2 and 7.5) and psychological ill health.[182,183] A recent meta-analytic review identified eight studies evaluating CRP and three studies evaluating IL-6 for their relationship with the development of depressive

symptoms in both women and men.[182] It was shown that elevated inflammatory biomarkers predicted depressive symptoms after adjustment for all confounding factors, with CRP being the stronger of the two predictors. Wium-Andersen and colleagues,[183] in a prospective population analysis of 73,000+ adults aged 20 to 100 yr, similarly, concluded that elevated CRP was associated with an increased risk for psychological distress and depression. In the current intervention, although the changes in inflammatory biomarkers were not related to the improvements observed in mood and HRQoL, associations were present between BF and VO_{2max} changes and the improved HRQoL general health factor. It is plausible that physically inactive individuals could positively affect inflammatory biomarker status and indices of mental health simultaneously following a programme of PA, as sedentary behaviour has been correlated with both.[184,185] Howard and colleagues[184] demonstrated association between sitting time and elevated CRP and fibrinogen, while Asztalos and colleagues[185] described the relationship between sitting time and five mental health indices (psychological distress, depression, anxiety, somatisation, and sleeping problems). As physical inactivity is characterised by a lack of skeletal muscle contraction, a possible mechanistic pathway to explain the aforementioned relationships might involve reduced expression of transcriptional coactivators thought to have anti-inflammatory effects via myokine release.[186] Furthermore, interruption to prolonged bouts of sitting with moderate intensity PA has been shown to modulate expression of various genes linked with anti-inflammatory processes.[187] A further mechanism linking sedentary behaviours, such as sitting or screen viewing time, with poor psychological health might simply involve the accompanying social isolation or reduced opportunities for development of social support networks[188]; both of which have been shown to negatively affect well-being and mood in adults.[189]

In Study 4, we reported an 11% increase in VO_{2max} following 8 wk of Latin-themed aerobic dance. This result is greater than that found by Barene and colleagues[75] (7% improvement), but less than that reported by Hovell and colleagues[71] (18% improvement) following 40 wk of Zumba fitness and 26 wk of Latin dance, respectively. Traditional (i.e., non-Latin) aerobic dance training studies have also reported comparable enhancements in VO_{2max} over similar time periods (7[190] and 8 wk[94]) as that used in the current work, albeit the

participants in these investigations were younger and displayed a higher pre-exercise VO_{2max}. The importance of improved VO_{2max} consequent to engagement in PA cannot be understated, especially given recent evidence indicating that enhanced cardiorespiratory fitness decreases overall mortality risk independently of BMI.[191,192] The current literature seems to support the hypothesis that measures of cardiorespiratory fitness are more important than measures of body fatness for prediction of overall mortality. Unfit individuals have twice the mortality risk, regardless of BMI, when compared with normal weight fit individuals; and overweight fit individuals have a similar risk for mortality as their normal weight fit counterparts.[192] Accordingly, PA specialists ought to focus on increasing PA levels in adults with the intention of improving, or at least maintaining, cardiorespiratory fitness through regular MVPA engagement. PA programmes in the overweight and obese that fail to report a decrease in BM may not necessarily be inconsequential in the context of overall health outcomes, especially if these adults are physically inactive and have a low (< 27.7 mL/kg/min)[191] initial cardiorespiratory fitness. From a psychosocial health promotion perspective, it would also seem prudent to encourage individuals to participate in forms of PA they find enjoyable (not necessarily limiting the choices to traditional modalities of exercise) as this could potentially increase the mental health benefits of PA[193] and the likelihood for adoption and adherence over time.[6,194]

In Study 2, it was demonstrated that both women and men rated the interest-enjoyment factor of the IMI highest following sessions of moderate to vigorous intensity Latin social dance. It was also shown that the psychosocial aspects of recreational dancing, assessed via the EBBS, were perceived to be the most beneficial, or important, to the participants. Taking part in PA primarily for reasons related to personal interest and enjoyment is a hallmark indicator of self-determined behaviour.[195] Although initial adoption of health-related activities may involve certain extrinsic factors,[7] it has been demonstrated that adherence to PA over time is associated more so with factors concerning intrinsic motives.[196] Intrinsically motivated individuals engage in tasks they find inherently interesting and enjoyable with no external incentives or rewards being necessary.[197] Self-determination theory applied to behavioural change for PA posits that sustained engagement in an activity occurs when the

fulfilment of competence, autonomy, and relatedness needs have been satisfied.[7] Thus, for individuals to adhere to PA they must find the task interesting, enjoyable, and challenging.[195] The fact that some individuals select particular activities to take part in while avoiding other activities can be explained, at least in part, by the social environment or context,[198] which can either facilitate or undermine an individual's intrinsic motivational drive.[197] Thus, the social contextual aspects of PA, especially during activities performed primarily for leisure, have been described as being of especial importance within the framework of self-determination theory.[197] Furthermore, the fact that Study 4 was designed in such a way that the participants themselves were free to self-select when and where they took part in the intervention classes (within the instructions provided at enrolment) likely facilitated PA and health-related autonomy. Moreover, our results are consistent with the findings of Allender and colleagues,[5] who in a systematic review, reported that adult participation in PA is mainly associated with motives related to enjoyment, social connectedness, and health enhancement.[5] Dance, irrespective of whether participation is oriented towards the development of dance technique or for aerobic exercise purposes, may indeed be a viable means of MVPA engagement that can foster enjoyment and pleasure (i.e., though music listening) and provide opportunity for skill mastery (i.e., improving dance competency over time) within a socially rich environment (i.e., dance performed in partners or within a group setting among peers).

In Studies 3 and 4, we demonstrated that Latin dance and Latin-themed aerobic dance favourably enhance psychological affect in physically inactive individuals with large magnitude effects. Specifically, SEES measures of well-being and distress improved acutely following classes of salsa dance and Zumba fitness, while factors of mood, assessed using the POMS-2, improved from pre- to post-dance following a Zumba fitness intervention. In a meta-analysis comprising 9000+ participants from one hundred five studies, aerobic PA was shown to positively regulate psychological affect with a medium effect size.[199] The authors noted, however, that baseline psychological affect was an important moderator in the analysis. Other investigators, similarly, have reported that exercise is associated with greater negative affect reductions[200]

and positive affect enhancements[201] in those self-reporting a poorer pre-exercise affective state. In our own research, measures of pre-dance psychological affect were incorporated into the statistical treatments used for analysis of affective change; thus, the observed large magnitude improvements would likely not have been due solely to baseline affective levels as this potential moderator had been taken into account. It is possible that our findings are a result of having recruited only physically inactive individuals. As adults with lower cardiorespiratory fitness and minimal habitual PA levels have been shown to self-report higher depressive symptoms and lower psychological well-being,[202,203] it is plausible that these individuals, therefore, have a larger potential for change in terms of mental health adjustment through exercise.

In addition to affective measures, we also evaluated change over time in HRQoL in Study 4. Little evidence is currently available establishing the efficacy of dance as a non-traditional modality of PA for the improvement of HRQoL, yet better HRQoL scores have been associated with traditional forms of total[69] and leisure PA[204] and higher levels of cardiorespiratory fitness[205] in otherwise healthy adults. HRQoL refers to the degree in which an individual's health impacts daily functioning and involves perceptions of well-being in both the physical and mental domains.[206] Therefore, it is plausible to assume that as Latin dance and Latin-themed aerobic dance are moderate to vigorous intensity[77,79] activities undertaken in a manner that fosters social connectedness,[78] engagement by non-exercisers may result in meaningful improvements in HRQoL. Our findings, however, showed that only two factors of the SF-36 related to the physical domain (physical functioning and general health) and two factors related to the mental domain (energy/fatigue and emotional well-being) improved post-intervention. Although our pre-intervention scores are consistent with those previously presented in a population sample,[207] our participants fared better across all factors when compared to those in the original validation work.[123] Furthermore, Samsa and colleagues[208] described a method of estimating clinically important differences in HRQoL scores and proposed a range of 3.0 to 5.0 on the SF-36 as being the minimal change necessary for a meaningful improvement. Intriguingly, our change scores in the intervention group were all > 5.0, lending support to the notion that it is indeed possible for physically inactive individuals to improve

meaningfully in certain, albeit not all, aspects of HRQoL through participation in dance.

8.3. Strengths and limitations

A strength of Studies 1, 2, and 3 is that all of the dance-related data were collected twice. Mean values were used for statistical analysis and reliability measures were established. One of the principal differences between evaluation of dance and traditional modalities of exercise commonly performed during laboratory-based physiological testing is that dance, at least in part, is self-selected in nature, unlike treadmill running at fixed speeds or cycle ergometry at fixed work rates. As such, it was decided in the initial design of the research studies to incorporate a duplicate data collection system, which would then result in smoothed values during data processing and, hence, a more robust dataset for statistical treatment. Regarding Study 4, a strength worth noting is that the retention rate was 87% over the course of the intervention. This is reasonably high considering that the participants were recruited from the local community (as opposed to convenience sampling methods being used, i.e., recruitment of only university students[67]) and laboratory-based measurements were taken (as opposed to only field measures being recorded[73]). Retention rates of other Latin dance interventions, for comparison purposes, are presented (Table 2.1). Furthermore, in Study 4 the average rate of attendance (compliance) for the intervention classes was 98%. This value is substantially higher than other Zumba fitness interventions where attendance rates were reported to be 71,[76] 74,[86] and 78%.[87] The high rate of attendance in Study 4 is likely a result of the ecologically valid nature of the study design, whereby the participants themselves were free to choose the instructor, location, and time of day of the classes attended. A further strength relating to all four studies undertaken, is that physiological data, such as VO_{2max} and resting and HR_{max}, were collected in the laboratory. In reviewing the literature, it is apparent that not all Latin dance and Latin-themed aerobic dance investigators have made use of equally rigorous methods of data collection. Examples include the recent salsa dance research of Emerenziani and colleagues,[26] where VO_{2max} was estimated via a bench stepping task (not measured using a laboratory-based graded exercise test performed using standard equipment), and Di Blasio and colleagues,[80] where HRR (used as a primary outcome measure of dance

intensity) was determined using self-reported resting HR and estimated HR_{max}, and the recent Zumba fitness intervention of Micallef,[87] where no laboratory-based measurements whatsoever were taken.

A limitation of the current research that warrants highlighting is the relatively small sample sizes obtained in all four studies. Attempts were made to recruit an appropriate number of participants for each of the studies within the limits of the resources that were available. These resources included: the number of months allocated for completion of each study within the time frame of the enrolled degree; the availability of laboratory days and times permissible to be booked by research students during this time; and compensation that could be awarded to the participants in exchange for volunteering their time for the research. Compensation included reimbursement of parking/transport costs to and from the university on laboratory testing days, reimbursement of the cost of attending the salsa dance and Zumba fitness sessions, and delivery of a personalised physiological report and health screen; an example of this document is presented in full (Appendices). It should be noted that performance-oriented studies in the dance literature that involve laboratory-based measurements often show comparable sample sizes to the ones obtained in the current research. Examples include the work of: Massidda and colleagues,[209] who recruited ten competitive Latin dancers; Twitchett and colleagues,[104] who recruited sixteen ballet students; Wyon and Redding,[210] who recruited seventeen professional contemporary dancers; and Bria and colleagues,[211] who recruited twenty-four competitive ballroom dancers. These studies were all published within the past decade and in four different peer-reviewed scientific journals. Two independent a priori sample size computations were performed for Study 4. The first estimation was made using the power.t.test function within R with the outcome measure of interest being VO_{2max}. Based on the results from Study 3, VO_{2max} mean ± standard deviation was input as 30.5 ± 4.7 mL/kg/min with an expected post-intervention improvement of 10%[212] (3.1 mL/kg/min). Alpha and power were set at 0.05 and 0.80, respectively. The resulting estimation came to seventeen intervention and seventeen control participants being required. The retention rate in Study 3 was 92% and based on this value an additional three participants were estimated to be required. Therefore, the final sample size estimation for Study

4 came to thirty-seven participants. The second computation was made using a web-based power and sample size calculator (statisticalsolutions.net). When the same input values were used, the resulting estimation came to fifteen participants required per group. Therefore, the final sample size estimation using the second method totaled thirty-three participants. Although only twenty-three individuals were successfully enrolled during the recruitment phase of Study 4, as discussed, all attempts were made to obtain a sample size that met the a priori computations performed.

A further limitation regarding Studies 1 and 2 is that more female participants were enrolled in the research than males. Efforts were made to recruit an even number of women and men. This was based on the fact that salsa is a partnered dance and therefore it is logical to assume that in real social dancing environments the number of females and males engaged in the activity at any given time would be roughly equal. It should be noted, however, that no data were collected to assess what the actual ratio between female and male recreational dancers is in established salsa venues in London, UK. Intriguingly, the majority of studies in the literature investigating partnered social dance for PA and health promotion purposes have recruited either women only or a combination of both sexes, whereby the number of female participants is often higher than the number of males. Example studies include the work of: Hovell and colleagues[71] and Lee and colleagues,[72] where only women were recruited; Pinniger and colleagues,[21] where the recruitment was 91% female; and Federici and colleagues,[73] where the recruitment was 65% female. An exception to this includes the work of Kreutz,[58] who collected survey data only without taking laboratory-based measurements; the recruitment was 41% female. The literature seems to suggest that other investigators may have also experienced more difficulty in the recruitment of male participants for research involving dance when compared with recruitment of females.

8.4. Practical applications and future research recommendations

Researchers of dance can use the combined triaxial accelerometry and HR telemetry technique developed in this research to monitor, in an activity-specific manner, individuals participating in dance, from both a health promotion point of view and from a performance-oriented perspective. The ActiGraph monitors used in this research are comfortable and unobtrusive to

wear. The ActiGraph is also the most validated[140] commercially available research grade PA monitoring system in use today. The ability to track changes in workload (i.e., in metrics of EE, SC, HR, or VM acceleration) over time during dance classes, rehearsals, or on stage performance may be of utility for both researchers and practitioners of dance alike. In terms of health promotion, PA specialists could, for example, evaluate dance interventions by using the monitors and described data processing techniques to assess how measures of caloric cost, steps taken, HR response, or body acceleration change during dance sessions in non-exercisers from when they initially commence activity to when proficiency in dance technique is attained. Furthermore, direct comparisons between dance (as a non-traditional modality of PA engagement) and traditional forms of exercise could be made, but with activity-specific objective data collection and processing methods used. This has not previously been reported in the literature and would likely be of use for a thorough understanding of the efficacy of dance-oriented PA promotion strategies. In terms of performance, characterisation of dance using the method of accelerometry is still a new technique in the field of dance research. The accelerometer value calibrations undertaken for Latin dance in the current work could potentially be undertaken for other genres of dance as well (i.e., contemporary or ballet). Moreover, age-specific (i.e., adolescent or adult) accelerometer value calibrations could be developed. Currently, physiological monitoring of dance during rehearsals and on stage performance in trained dancers is almost exclusively undertaken using HR recording (some of the limitations of which have been outlined in Section 2.7). Combining motion sensing technology with HR recording would not be additionally burdensome on the dancer. Once the monitors have been acquired and the value calibrations undertaken, only minimal practitioner training would be required in order to collect, process, and interpret data. Psychologically, the acute and long-term improvements in indices of mental health observed in the current research indicate that a non-traditional modality of PA, such as dance, can indeed be efficacious in a health promotion context for the development of psychosocial wellness. Latin dance and Latin-themed aerobic dance could therefore be utilised as a creative means of leisure and physical movement to foster enhancements in mental health in non-clinical cohorts; ballroom dance, for

example, in a similar manner, has already been investigated as a medium of therapy for individuals with mental illness.[213]

Recommendations for future research include, firstly, the use of true experimental (i.e., randomised controlled study) designs as opposed to the continued use of observational[88,89,90] and quasi-experimental designs,[76,86,87] where the ability to make inferences from the results is less clear. This is exemplified in the recent quasi-experimental interventions of Araneta and Tanori,[76] Krishnan and colleagues,[86] and Micallef,[87] where all three research groups investigated the physiological responses to Zumba fitness in a health promotion context in women; in all three cases neither random assignment nor a non-exercise control group were used. These investigations were all published in 2014. Secondly, future Latin dance and Latin-themed aerobic dance studies should incorporate assessments of musculoskeletal and functional health change over time, such as hamstring and low back flexibility, shoulder mobility, lower limb muscular strength, and bone mineral density and mass. These PA and health-related outcomes have not yet been fully explored in the dance literature in non-clinical adult cohorts, yet have been studied in specifically middle-aged[214] and older[55,215] adults with promising findings reported. Indeed, in a review of the physical benefits of dance in healthy adults it was concluded that participation is likely effective for increasing lower extremity flexibility, endurance, strength, and bone mineral content.[57] Thirdly, future Latin dance and Latin-themed aerobic dance studies ought to be undertaken from a physiological and psychological perspective simultaneously. Taking part in dance will likely always provide a certain degree of physical stimulus relevant to the promotion of health through PA and will likely also be beneficial for certain aspects of mental health. If dance-related research is conducted whereby both physiological and psychological (i.e., confidence, enjoyment, motives, social connectedness, skill mastery, or passion[216]) parameters are simultaneously measured, potential relationships between these variables could then be examined. Quantifying these associations may assist our understanding of the viability of dance as a non-traditional holistic form of PA engagement for adults.

9 GENERAL CONCLUSION

This research explored the activities of salsa dance and Zumba fitness from a holistic (i.e., a physiologically- and psychologically-oriented) perspective using quantitative techniques for collection of data in both laboratory-based and ecologically valid environments. Although the Latin genre of dance is considered to be broad, these two particular dance styles were chosen for evaluation due to their popularity[4,28] in both Latin and non-Latin communities. Partnered salsa dance and non-partnered Zumba fitness are physical pursuits engaged in by individuals of a wide range of ages. The presented results indicate that Latin dance and Latin-themed aerobic dance, when taken part in primarily for (non-competitive) leisure purposes, are indeed efficacious modalities of PA in terms of physical and mental health enhancement. Public health researchers and practitioners interested in dance as a potential medium for PA promotion may consider the findings of this research relevant, especially given that organisations in both the health and arts sectors continue to encourage community dance participation in adults as a means of increasing PA and socialisation.[31,158] In summary, using validated measurement methods, it was demonstrated that Latin dance and Latin-themed aerobic dance, generally engaged in for the development of dance technique or for aerobic exercise purposes, improve measures of cardiorespiratory fitness, body composition, and inflammatory biomarkers in relation to cardiovascular health. Moreover, it was shown that participation fosters a positive psychological outlook alongside feelings of interest, enjoyment, and competence in dance. Reductions in perceived distress and enhancements in well-being, mood, and HRQoL were also observed. Adults seeking to become more physically active could take part in either two 2 h salsa dance sessions (social dancing) or two 1 h instructor-led group classes of Zumba fitness weekly to meet the WHO-recommended PA guidelines for physical and psychosocial health maintenance.[12,141] The current work supports the notion that Latin dance is an

efficacious health-enhancing leisure activity as participation appears to contribute positively to physical, mental, and social wellness in non-clinical adults; the current WHO definition of health, formalised over half a century ago, is "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".[217]

In Study 1, a laboratory-based dance trial was undertaken to quantify the physiological and PA parameters associated with engagement in Afro-Cuban salsa. Research grade motion sensing and HR monitors were utilised in order to value calibrate EE and SC prediction equations for use with the ActiGraph GT3X series of accelerometers. Although these devices are commonly used by PA researchers, investigators of dance have not previously performed dance-specific accelerometer value calibrations and therefore have had to rely solely on generalised methods of conversion of the accelerometer output signal into relevant metrics. Validation of the technique was successful when compared with gold standard methods of laboratory-based measurement. As performance of dance is generally characterised as being self-selected in nature, statistical testing was undertaken in order to establish a measure of reliability for the new technique. This study is the first published investigation (Journal of Dance Medicine & Science) to establish a criterion-referenced activity-specific objective measurement method for quantification of Latin dance parameters for use in PA and health promotion research.

The monitoring devices and data processing method devised in the aforementioned study were then used to examine the responses to Latin partnered social dance to salsa music when performed in a naturalistic setting. In Study 2, intermediate to advanced non-professional Latin dancers were recruited to wear the equipment while taking part in the activity in real salsa venues in London, UK. No previous investigations have attempted to record the physiological responses to salsa dance using the method of accelerometry under ecologically valid conditions. For the psychological assessment, PB of recreational salsa dancing were recorded and state IM for dance was captured using previously validated self-report instruments. The publication of this study (Human Movement Science journal) is the first instance of the physiological responses to Latin partnered social dance to salsa music being reported when objectively measured under real conditions using activity-specific techniques.

As Zumba fitness, currently the world's largest branded fitness programme,[30] is typically attended as an instructor-led group class, this format was selected for evaluation in Study 3. Non-exercising community-recruited women were enrolled in the research and undertook sessions of both Zumba fitness and salsa dance. A true counterbalanced design was used to assign the order of the classes and all participants took part in two sessions each of both class types. Short-term change in two measures of psychological affect was assessed using a previously validated exercise-specific questionnaire. The physiological comparison between class types indicated greater responses during Zumba fitness in comparison with salsa dance; however, no pre- to post-class psychological differences between class types were revealed. This is the first published study (Journal of Sport and Health Science) to assess Latin dance and Latin-themed aerobic dance from a physical and mental health perspective simultaneously using subjective and objective methods and to present correlations between measures of both in the context of psychosocial health-oriented PA promotion.

The findings of the three aforementioned investigations were then used to design a randomised controlled study of Zumba fitness in Study 4 to test the hypotheses that cardiorespiratory fitness, inflammatory biomarkers, cardiovascular risk factors, and mental health would improve in a cohort of overweight and physically inactive women following engagement in 8 wk of Latin-themed aerobic dance. A novel aspect of the research that warrants highlighting is that the participants were recruited from the local (Royal Borough of Kingston) community and the Zumba fitness classes attended were self-selected (in terms of instructor, location, and time of day) by the participants themselves, thus increasing representativeness of what non-exercising individuals would actually do when commencing an exercise programme. In addition to the pre- and post-intervention laboratory-based assessments, HR and movement registration data were collected in all dance sessions attended by the intervention participants (118 h of Zumba fitness data were analysed). From these results it was concluded that Zumba fitness is a vigorous intensity form of aerobic PA. This study is being presented in poster format at the American College of Sports Medicine 2015 annual meeting (26 –

30 May 2015; San Diego, CA, USA) and has been submitted to a peer-reviewed scientific journal for consideration for publication.

The current work demonstrates that participation in dance contributes positively to physical, mental, and social wellness in adults. Latin dance and Latin-themed aerobic dance, therefore, ought to be considered efficacious health-enhancing leisure activities. Although motives for initial engagement and adherence thereafter are likely varied between individuals, both salsa dance and Zumba fitness demand MVPA intensity levels and can be considered social or recreational activities that engage adults in physical pursuits that are not necessarily thought of as traditional exercise per se. The perception that this genre of dance is not actual exercise likely contributes to its current, and growing, popularity in both Latin and non-Latin communities.

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APPENDICES

EBBS

Exercise benefits/barriers scale

For each of the statements below, please indicate your level of agreement or disagreement from the provided descriptors.

Strongly Agree

Agree

Disagree

Strongly Disagree

1. I enjoy exercise.
2. Exercise decreases feelings of stress and tension for me.
3. Exercise improves my mental health.
4. Exercising takes too much of my time.
5. I will prevent heart attacks by exercising.
6. Exercise tires me.
7. Exercise increases my muscle strength.
8. Exercise gives me a sense of personal accomplishment.
9. Places for me to exercise are too far away.
10. Exercising makes me feel relaxed.
11. Exercising lets me have contact with friends and persons I enjoy.
12. I am too embarrassed to exercise.
13. Exercising will keep me from having high blood pressure.
14. It costs too much to exercise.
15. Exercising increases my level of physical fitness.
16. Exercise facilities do not have convenient schedules for me.
17. My muscle tone is improved with exercise.
18. Exercising improves functioning of my cardiovascular system.
19. I am fatigued by exercise.
20. I have improved feelings of well being from exercise.
21. My spouse (or significant other) does not encourage exercising.

22. Exercise increases my stamina.
23. Exercise improves my flexibility.
24. Exercise takes too much time from family relationships.
25. My disposition is improved with exercise.
26. Exercising helps me sleep better at night.
27. I will live longer if I exercise.
28. I think people in exercise clothes look funny.
29. Exercise helps me decrease fatigue.
30. Exercising is a good way for me to meet new people.
31. My physical endurance is improved by exercising.
32. Exercising improves my self-concept.
33. My family members do not encourage me to exercise.
34. Exercising increases my mental alertness.
35. Exercise allows me to carry out normal activities without becoming tired.
36. Exercise improves the quality of my work.
37. Exercise takes too much time from my family responsibilities.
38. Exercise is good entertainment for me.
39. Exercising increases my acceptance by others.
40. Exercise is hard work for me.
41. Exercise improves overall body functioning for me.
42. There are too few places for me to exercise.
43. Exercise improves the way my body looks.

Example Information Sheet and Informed Consent Form

Kingston University Zumba fitness research study

You are being invited to participate in a Kingston University PhD study and it is important for you to understand why the research is being conducted and what will be involved. Please read the following information carefully and do not hesitate to ask if you require any further information.

Organisation of the study

The principal investigator is Mr. Pablo Domene and the research supervisors are Drs. Hannah Moir and Elizabeth Pummell. Complete contact information is as follows.

Mr. Pablo Domene / Email: k1170523@kingston.ac.uk
Dr. Hannah Moir / Email: h.moir@kingston.ac.uk
Dr. Elizabeth Pummell / Email: e.pummell@kingston.ac.uk

Purpose of the study

The purpose of the study is to examine the physiological and psychological responses to Zumba fitness (Latin-themed aerobic dance).

Selection criteria

You have been selected as a possible participant for the study because you have expressed interest in the research and you: are a non-smoking female between the ages of 18 to 64; are currently exercising at a moderate or higher intensity for less than half an hour per week; have a body mass index of 25 or more; and have not previously attended more than one Zumba fitness session.

Refusal to participate

No obligation to accept this invitation is assumed and you may choose not to participate in the study if you wish. If you decide to participate you will be required to complete the informed consent and physical activity readiness and frequency sections of this document (a paper copy will be provided for you).

You will still be able to withdraw from the study at any time and for any reason whatsoever if you choose.

Study requirements

You will be required to attend two 90 minute morning appointments at Kingston University and participate in Zumba fitness sessions once to twice per week over a period of 8 weeks.

Your height, weight, body composition, and blood pressure will be measured. A fitness evaluation will be conducted. This involves walking on a treadmill for about 10 to 15 minutes. A small blood sample will be collected by Dr. Hannah Moir so that we can check levels of your cholesterol, white blood cells, C-reactive protein, and interleukin-6. It is important not to have eaten for eight hours prior to the appointment time, which is why we will arrange a morning visit that is convenient for you. Additionally, you will be asked to complete a short psychological questionnaire that asks you about your mood and health-related quality of life. During one of the weeks you will be given a watch to wear on the wrist throughout the daytime. It is an electronic monitor that records how much physical movement you are involved in. During the same week you will be asked to write down a daily log of all food items that have been eaten.

You will be attending one to two Zumba fitness sessions per week over the eight weeks of the study at times and locations that are convenient for you. During the classes you will be required to wear the wrist watch and also a small chest strap monitor which will go underneath your clothing. This will record your heart rate during the Zumba fitness sessions.

Please let us know if you are using any anti-inflammatory, anti-coagulant, or anti-platelet medication, or any medication to control your cholesterol or blood pressure. Please also let us know if you have had any major injuries or illnesses in the past six months, or if you are pregnant or planning on becoming pregnant over the course of the study period.

Benefits of participation

The study will assist us in determining how well Zumba fitness meets the recommended guidelines for physical activity involvement. After the study, you will be provided with a comprehensive health screen and fitness report detailing your participation, including: how many calories of energy you expended; how many steps you took; what your heart rate response was; and how much time you spent in moderate and vigorous physical activity during the Zumba fitness sessions.

Disadvantages of participation

Taking part in any form of physical activity or exercise can involve a small risk, even for healthy adults. If you experience any dizziness, unusual sensations in your chest, or shortness of breath, you should immediately cease what you are doing. Your personal safety and well-being is our primary concern. In the event that something goes wrong, your legal rights will not be compromised in any way through your agreement to participate in the study.

Collection of data, samples, and personal information

Personal information collected will remain confidential and will be accessible only to the researchers named. Documents will be stored in a locked cabinet and electronic data will be stored on a password protected computer and securely backed up onto the Kingston University network. Blood samples taken for analysis will be disposed of following standard laboratory protocols.

Study results

Completion of the study will contribute in part to fulfilment of the principal investigator's PhD degree to be awarded by Kingston University. A manuscript of the study will be submitted to a peer-reviewed scientific journal for publication. You will not be identified as a participant and all personal information will remain confidential.

Participant's statement

I confirm that I have read and understood the invitation and information sections of this document.

I confirm that I am aware of the purpose, benefits, and risks of participating in the study.

I confirm that my participation is voluntary and that I can withdraw at any time.

I understand that all information obtained will be kept confidential.

I understand that data collected for the study may be published and that I will not be identified as a participant.

I confirm that full contact details have been provided should I wish to seek further information from the research team.

Participant's signature . . . . . .

Date . . . . . .

Principal investigator's statement

I confirm that I have explained the study and implications of participation to the participant without bias.

I believe that the consent is informed and that the participant understands the implications of participating.

Principal investigator's signature . . . . . .

Date . . . . . .

Example Physiological Report and Health Screen

Physiological report and health screen prepared by

Mr. Pablo Domene
School of Life Sciences
Kingston University
Penrhyn Road
Kingston upon Thames
KT1 2EE
Email: k1170523@kingston.ac.uk

Participant name

-

First appointment date

15 August 2013

Pre-intervention measurements

Age:	31 yr
Stature:	156.9 cm
Body mass:	67.9 kg
Body mass index:	27.6 kg/m^2
Body fat:	33.8%
Systolic blood pressure:	109 mmHg *
Diastolic blood pressure:	72 mmHg *
Resting heart rate:	90 beat/min **
Cardiorespiratory fitness:	24.6 mL/kg/min ***
White blood cell count:	7.1 x 10^9 cell/L ****

Second appointment date

10 October 2013

Post-intervention measurements

Age:	31 yr
Stature:	156.9 cm
Body mass:	67.4 kg
Body mass index:	27.4 kg/m^2
Body fat:	31.6%
Systolic blood pressure:	104 mmHg *
Diastolic blood pressure:	70 mmHg *
Resting heart rate:	92 beat/min **
Cardiorespiratory fitness:	31.9 mL/kg/min ***
White blood cell count:	4.6 x 10^9 cell/L ****

Normative values

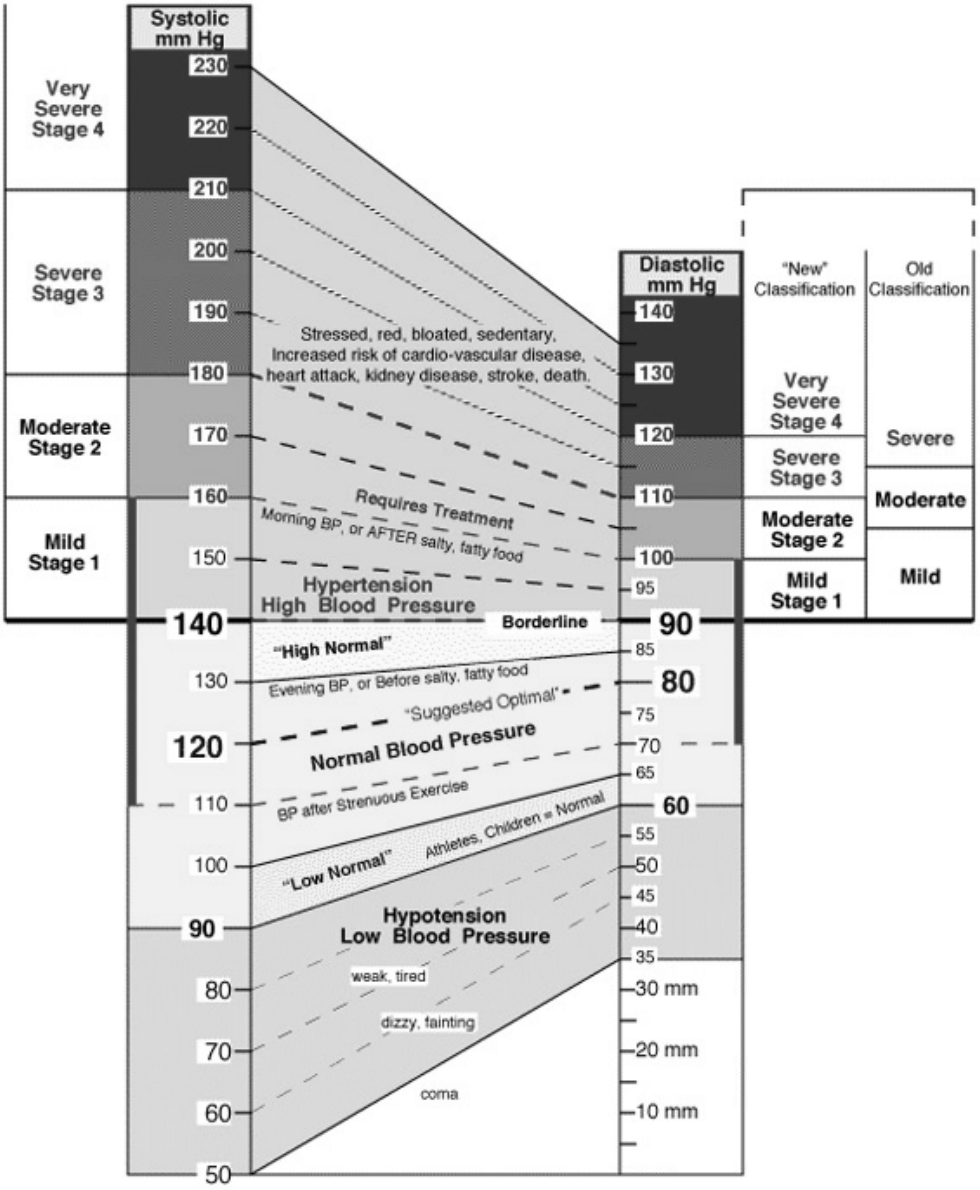
* see blood pressure diagram[218] overleaf

** 45 – 95 beat/min (within this range, lower is better)

*** 50th percentile = 35.2 mL/kg/min (for women aged 30 – 39 yr)

**** 3.5 – 10.5 x 10^9 cell/L (within this range, lower is better)

Blood pressure diagram



Zumba fitness measurements (average of classes attended)

Class time:	60.0 min
Time in sedentary and light intensity physical activity:	7.4 min
Time in moderate intensity physical activity:	20.3 min
Time in vigorous intensity physical activity:	32.3 min

Moderate intensity physical activity values

Energy expenditure:	4.9 MET
Step count:	117 step/min
Average heart rate reserve:	25%
Maximal heart rate reserve:	55%

Vigorous intensity physical activity values

Energy expenditure:	8.0 MET
Step count:	137 step/min
Average heart rate reserve:	28%
Maximal heart rate reserve:	71%

Total values

Energy expenditure:	414 kcal
Step count:	6942 step

American College of Sports Medicine health maintenance aerobic physical activity zone

40 – 85% of heart rate reserve

American Journal of Preventative Medicine health maintenance daily step count recommendation

≥ 100 step/min for at least 30.0 min daily or an accumulated total of ≥ 10,000 step/day

Compendium of Physical Activities health maintenance physical activity intensity levels

≤ 1.5 MET = sedentary

1.6 – 2.9 MET = light intensity physical activity

3.0 – 5.9 MET = moderate intensity physical activity

≥ 6.0 MET = vigorous intensity physical activity

Compendium of Physical Activities comparison physical activities

3.0 MET = walking slowly at 4.0 km/hour

4.3 MET = walking at 5.6 km/hour

5.0 MET = walking quickly at 6.4 km/hour

7.0 MET = jogging slowly at 7.2 km/hour

8.3 MET = jogging at 8.0 km/hour

9.0 MET = jogging quickly at 8.4 km/hour

9.8 MET = running at 9.7 km/hour

Example Research Poster Advertisement

ARE YOU INTERESTED IN
8 WEEKS OF FREE

ZUMBA® FITNESS

CLASSES? TAKE PART IN A
KINGSTON UNIVERSITY
PHD RESEARCH STUDY!

We are investigating the physical and mental health benefits of engagement in Zumba® fitness (Latin-themed aerobic dance) classes.

If you are female, between the ages of 18 and 64, and not currently exercising you may be eligible for enrolment.

Contact Mr. Pablo A. Domene and Dr. Hannah J. Moir at Kingston University, School of Life Sciences for details.

EMAIL:
k1170523@kingston.ac.uk

IMI

Intrinsic motivation inventory

For each of the statements below, please indicate your level of agreement or disagreement from the provided descriptors.

Strongly Disagree

Disagree

Disagree Somewhat

Uncertain

Agree Somewhat

Agree

Strongly Agree

1. I enjoyed salsa dancing very much.
2. I think I am pretty good at salsa dancing.
3. I put a lot of effort into salsa dancing.
4. It was important to me to do well at salsa dancing.
5. I felt tense while salsa dancing.
6. I tried very hard while salsa dancing.
7. Salsa dancing was fun.
8. I would describe salsa dancing as very interesting.
9. I felt pressured while salsa dancing.
10. I was anxious while salsa dancing.
11. I didn't try very hard at salsa dancing.
12. After salsa dancing for a while, I felt pretty competent.
13. I was very relaxed while salsa dancing.
14. I am pretty skilled at salsa dancing.
15. Salsa dancing did not hold my attention.
16. I couldn't salsa dance very well.

Physical Activity Readiness Questionnaire

PAR-Q & you: a questionnaire for people aged 15 to 69

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active. If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor. Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly, check YES or NO.

Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Do you feel pain in your chest when you do physical activity?

In the past month, have you had chest pain when you were not doing physical activity?

Do you lose your balance because of dizziness or do you ever lose consciousness?

Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions

Talk with your doctor by phone or in person before you start becoming much more physically active or before you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES. You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice. Find out which community programs are safe and helpful for you.

If you answered NO honestly to all PAR-Q questions

You can be reasonably sure that you can start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go. You can take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

Delay becoming much more physically active

If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or if you are or may be pregnant – talk to your doctor before you start becoming more active.

Please note

If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Note

If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

Name . . . . . .

Signature . . . . . .

Date . . . . . .

Witness . . . . . .

Informed use of the PAR-Q

The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

Note

This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

POMS-2

Profile of mood states 2nd edition short form for adults

For each of the statements below, please select a number that best describes how you have been feeling during the past week, including today.

0 - Not At All
1 - A Little
2 - Moderately
3 - Quite A Bit
4 - Extremely

1. Friendly.
2. Tense.
3. Angry.
4. Worn out.
5. Lively.
6. Confused.
7. Considerate.
8. Sad.
9. Active.
10. Grouchy.
11. Energetic.
12. Panicky.
13. Hopeless.
14. Uneasy.
15. Unable to concentrate.
16. Fatigued.
17. Helpful.
18. Nervous.
19. Miserable.
20. Muddled.
21. Bitter.
22. Exhausted.

23. Anxious.
24. Good-natured.
25. Helpless.
26. Weary.
27. Bewildered.
28. Furious.
29. Trusting.
30. Bad-tempered.
31. Worthless.
32. Vigorous.
33. Uncertain about things.
34. Drained.
35. Enthusiastic.

RPE

Rating of perceived exertion scale

Please select a number that best describes how much you are exerting yourself at the moment.

6.
7. Very, very light.
8.
9. Very light.
10.
11. Fairly light.
12.
13. Somewhat hard.
14.
15. Hard.
16.
17. Very hard.
18.
19. Very, very hard.
20.

SEES

Subjective exercise experiences scale

For each of the statements below, please select a number that best describes how you are feeling at the moment.

Not At All

1

2

3

4

5

6

7

Very Much So

1. Great.
2. Awful.
3. Drained.
4. Positive.
5. Crummy.
6. Exhausted.
7. Strong.
8. Discouraged.
9. Fatigued.
10. Terrific.
11. Miserable.
12. Tired.

SF-36

RAND 36-item health survey 1.0

For each of the questions below, please select the best answer.

1. In general, would you say your health is? Excellent; Very Good; Good; Fair; Poor.
2. Compared to one year ago, how would you rate your health in general now? Much better than one year ago; Somewhat better now than one year ago; About the same as one year ago; Somewhat worse now than one year ago; Much worse now than one year ago.
3. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much? Yes, limited a lot; Yes, limited a little; Not limited at all.

a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.
b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.
c. Lifting or carrying groceries.
d. Climbing several flights of stairs.
e. Climbing one flight of stairs.
f. Bending, kneeling, or stooping.
g. Walking more than a mile.
h. Walking several blocks.
i. Walking one block.
j. Bathing or dressing yourself.

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health? Yes; No.

a. Cut down on the amount of time you spent on work or other activities.
b. Accomplished less than you would like.
c. Were limited in the kind of work or other activities.
d. Had difficulty performing the work or other activities (for example, it took extra effort).

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (e.g. feeling depressed or anxious)? Yes; No.

a. Cut down on the amount of time you spent on work or other activities.

b. Accomplished less than you would like.

c. Didn't do work or other activities as carefully as usual.

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups? Not at all; Slightly; Moderately; Quite a bit; Extremely.

7. How much physical pain have you had during the past 4 weeks? None; Very mild; Mild; Moderate; Severe; Very severe.

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? Not at all; A little bit; Moderately; Quite a bit; Extremely.

9. These questions are about how you feel and how things have been with you during the past 4 weeks. Please give the one answer that is closest to the way you have been feeling for each item. All of the time; Most of the time; A Good Bit of the time; Some of the time; A little of the time; None of the time.

a. Did you feel full of life?

b. Have you been a very nervous person?

c. Have you felt so down in the dumps that nothing could cheer you up?

d. Have you felt calm and peaceful?

e. Did you have a lot of energy?

f. Have you felt downhearted and blue?

g. Did you feel worn out?

h. Have you been a happy person?

i. Did you feel tired?

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives etc.)? All of the time; Most of the time; Some of the time; A little of the time; None of the time.

11. How TRUE or FALSE is each of the following statements for you? Definitely true; Mostly true; Don't know; Mostly false; Definitely false.

a. I seem to get sick a little easier than other people.

b. I am as healthy as anybody I know.

c. I expect my health to get worse.

d. My health is excellent.

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