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QUANTIFYING AND COMPARING ACTIVITY IN GROUP EXERCISE CLASSES – A LITERATURE REVIEW

Aimee Harvey
Faculty of Science Health Education and Engineering, University of the Sunshine Coast, Maroochydore, QLD, Australia

ABSTRACT

The aim of this review was to evaluate and compare physical activity levels and physical responses of group exercises and evaluate methods of measuring these classes. The popularity of modern group exercise classes is evident by the more than 3 million classes per week offered by Les Mills International and the 81% of fitness business in Australia that offer group fitness classes. While general dance style aerobics have been researched, limited insight has been made into modern group exercise classes, leaving a gap in the knowledge of best practices when prescribing the various styles and programs as a healthy activity and measuring classes to accurately reflect physiological benefits. The purpose of this article is to present an overview of documented research and where possible identify gaps in knowledge in order to make recommendations for further study. A literature search was conducted in ProQuest, PubMed, Google Scholar, current reports and documentation was also sought through Fitness Australia and Les Mills International. There is an extensive amount of literature available exploring the benefits of more established techniques such as yoga, Tai Chi, Pilates and even dance style aerobics. However, when these styles of exercise are combined, or modernised with new techniques or equipment, the scope of literature is limited. Research available is restricted by inconsistencies in the type of equipment used, participants fitness level, variation in class structure, and instructor delivery.

Keywords: mind–body, martial arts, physical fitness, energy expenditure, heart rate

INTRODUCTION

Aerobic Dance originated in 1969 and was designed as a dance exercise program for a predominately female middle-class audience. Original aerobic dance programs consisted of a combination of ballet, jazz, disco, modern dance, calisthenics, stretching and strengthening exercises. (Garrick & Requa, 1988) Aerobics in its current form is a blend of various techniques derived from many forms such as athletics, gymnastics, dance, martial arts, yoga and weight training and consequently lacks consistency in basic terminology in current literature. The terms 'aerobic dance', as identified in early literature is often used interchangeably with 'group exercise activities'. Originally titled 'aerobics' or 'dance style aerobics', this name has evolved to the more modern 'group fitness' or 'group exercise' classification. This document will use the terms 'group exercise' to encompass organised group training programs as a whole. Specific programs and types of classes will then be referred to by their commercial name.

As a result of the growth and diversity of the group exercise industry, there are now a number of successful group exercise based programs. (Rixon,

Rehor, & Bemben, 2006) Les Mills International (LMI) is the world's largest provider of pre-choreographed group exercise classes with 90,000 certified instructors teaching its 10 programs in 14,000 licensed gyms, within 80 countries around the world. Les Mills International has been heralded as one of the world's biggest producers of branded exercise classes and has established a system of standardising movement where all programs have the advantage of being consistently taught as strictly defined. (Parviainen, 2011) A quote in The International Health, Racquet and Sports club Association (IHRSA) magazine in 2003 has credited LMI with 'doing for group exercise what McDonalds did for hamburgers'. (Les Mill International Limited, 2012) Worldwide participation in Les Mills classes equates to more than 3 million workouts each week and LMI aims to increase this to 20 million workouts per week by the year 2020. (Les Mills International Limited, 2012)

According to the 2012 Fitness Industry Work Force Report, there are a total of 7654 registered group instructors in Australia. (Fitness Australia, 2012) The report states that group exercise classes have been a driver of growth in the fitness industry over the past five years. This is due to their appeal to a wider market and has assisted fitness centers in attracting greater numbers of female clients. (Fitness Australia, 2012) The 2008 Australian Fitness Industry Profile reports 81% of fitness businesses offered group exercise classes. (Fitness Australia, 2009) This translates to 1,291 registered fitness businesses in Australia (Fitness Australia, 2011) providing an average of 23 group exercise classes per week (Fitness Australia, 2009), or nearly 30,000 classes with more than 750,000 participants per week.

Overall, the most commonly offered group exercise classes in Australia are strength and resistance classes (77%), flexibility/stretching abdominal classes (74%), boxing/combat classes (72%), and Circuit training (71%) (Figure 1). (Fitness Australia, 2009) In 2009–10 the aerobics/fitness category of exercise was amongst the top ten physical

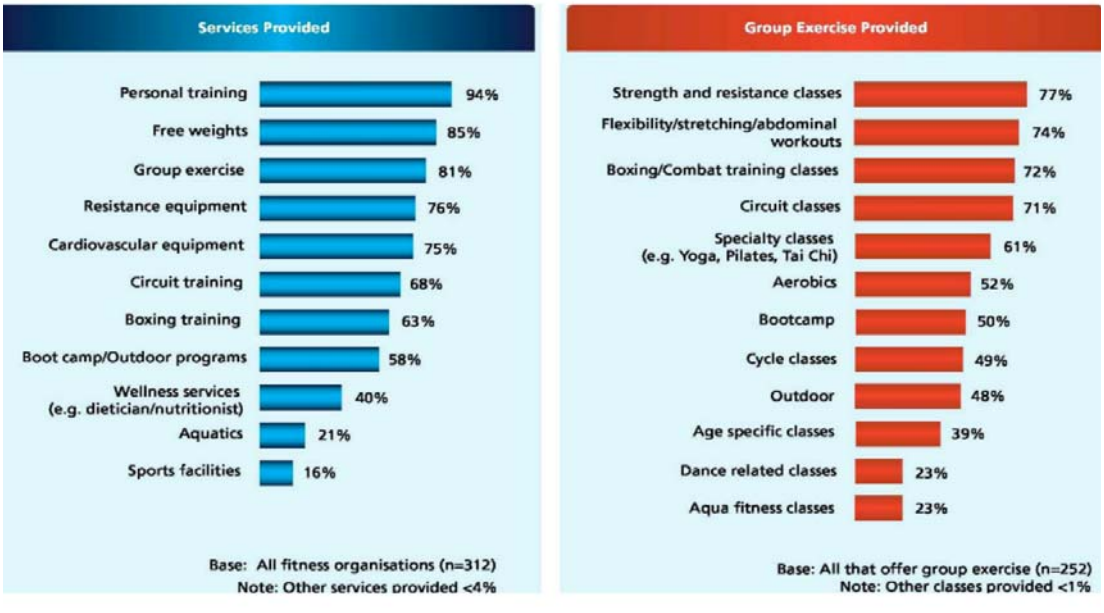

FIGURE 1: RESULTS OF FITNESS AUSTRALIA 2008 INDUSTRY PROFILE REPORT SURVEY.

Questions asked: Q4. Below are a number of fitness related services. Please indicate which of them your business/center provides; Q5a. Which of the following categories of group exercise does your business/center offer?

recreation participation activities for both men and women. Similarly in 2009–10, yoga classes also featured in the top 10 physical recreation participation activities for women. (Australian Bureau of Statistics, 2011b)

Les Mills Internationals' programs are designed to accommodate varying fitness levels, are easily accessible and widely used in not only in suburban centers, but also in remote areas of Australia. The LMI classes are among the top six most popular group fitness categories provided by the Australian Fitness Industry.

A variety of physiological responses to group exercise have been reported in the literature. A lack of consistency with choreography, and other variables, such as the type of step, the level of impact of the step, arm movements and cadence of music, and intensity of a class will impact on the ability to use the results from previous research. Research involving pre-choreographed programs such as the Les Mills programs can control some of these variables by establishing identical music and choreography with instructors following strict guidelines and delivering the same choreography to the same music, thus standardising class and exercise performance.

Les Mills Asia Pacific have over 1000 clubs licensed with LMI programs throughout Australia and South East Asia (Les Mills International Limited). The first program to be released in Australia was Bodypump™, which was first demonstrated at the Australian fitness convention, Filex, in 1996. Bodypump™ remains LMI's most popular program being licensed to more than 12,000 facilities around the world. This is followed by Bodyattack™ in 1997, which is offered in almost 1300 venues within the UK alone accounting for one fifth of all health and fitness facilities within the UK. (Felstead, Fuller, Jewson, Kakavelakis, & Unwin, 2007) Other globally popular programs include Bodybalance™ and Bodycombat™, released internationally in 1998 and 1999 respectively. (Les Mills International Limited, 2012)

LITERATURE REVIEW

Bodypump™ was first demonstrated at the Australian fitness convention Filex in 1996. The design of a Bodypump™ workout is intended to provide a comprehensive total body weight-training program aiming to improve strength, muscular endurance and general fitness. The class is choreographed to music and uses a combination of barbells, body-weight exercises and free-weight plates. Participants select weights based on the target muscle group for the specific song or track and their own personal goals. Bodypump™ is unique in that it does not follow a traditional progressive resistance program of sets and repetitions or a circuit weight format. Bodypump™ classes are 55 minutes in duration and contain 10 'tracks' or songs, each lasting from 4–7 minutes. Participants perform between 70–100 repetitions per body part, totaling as many as 800 repetitions in a single workout. The class starts with an opening warm-up, followed by eight tracks, each targeting specific muscle groups, finishing with a static stretch cool down.

Stanforth, Stanforth and Homeke completed the first published study on Bodypump™ in 2000. (Stanforth, Stanforth, & Hoemeke, 2000) The purpose of the study was to determine the physiologic and metabolic responses to a Bodypump™ workout, and compare findings with previously published studies on circuit weight training. This study measured maximal oxygen consumption (VO_2max), heart rate, energy expenditure, and rate of perceived exertion (RPE) during a typical Bodypump™ workout from 15 male and 15 female participants aged 27.3 ± 4.3 years.

A similar study, completed in 2003 with only 10 subjects (5 male and 5 female) aged 32.7 ± 4.2 years (Lythe & Pfitzinger, 2003), compared VO_2max and heart rate responses between a Bodypump™ class and 60 minutes of cycling. A summary of the results from these two studies is presented in Table 1. The mean average oxygen consumption (VO_2 in $ml.kg^{-1}.min^{-1}$) and mean

heart rate for the two studies of a Bodypump™ class were considerably different (Table 1). Reasons for this include different sample sizes (30 compared with only 10), and more importantly the methods of testing the VO_2max classes. Both studies used a metabolic cart to measure oxygen consumption, which is a restrictive piece of equipment, meaning that participants may not have been able to perform exercises how they were intended. Both studies indicate that the intensity of a single Bodypump™ workout is less than the 50–85% or VO_2max, as recommended by the American College of Sports Medicine. (Thompson, 2010) Research quantifying basic physiological measures and energy output for Bodypump™ requires further investigation, in order to provide more detailed data on the value of Bodypump™.

The stated aim by LMI of a Bodypump™ workout is to improve muscular strength and endurance, rather than aerobic fitness. (Les Mills International Limited, 2012) Oliveira et al. examined training responses in 15 untrained women comparing metabolic, cardiovascular and neuromuscular parameters during a Bodypump™ session. (Oliveira et al., 2009) Results show that a Bodypump™ session promoted neuromuscular conditions (muscular activation and fatigue state) that may be enough to induce improvements in strength. Following on from this initial study Oliveira et al. (Greco et al., 2011) conducted a second study measuring improvements in neuromuscular and metabolic fitness over 12 weeks of Bodypump™ and report significant improvement in maximal muscle strength and endurance of the lower limbs, coupled with a reduction in metabolic and cardiovascular stress. One repetition maximum (1 RM) squats improved by 33.1% within the training group of 9 females. Researchers also found that the training program also increases maximal isometric voluntary contraction by 13.6% during squats and lunges. These results support the outcomes promoted by LMI for a Bodypump™ class.

These findings, although varied, generally demonstrate positive outcomes in terms of the physiological benefits of a Bodypump™ class although further research is needed to quantify the physiological effects more definitively. Literary evidence suggests a lack of clarity and limited body of knowledge regarding physiological effects of a Bodypump™ class. Further, the literature suggests researchers have not yet identified the most accurate way to measure activity and energy expenditure in group exercise classes.

Bodybalance™ is a low intensity workout inspired by yoga, Tai Chi and Pilates. (Les Mills International Limited, 2012) Controlled breathing, concentration and a structured series of stretches and poses comprise this workout. The promoted benefits of this class are to increase

TABLE 1: COMPARISON OF MEAN RESULTS FROM AND ENTIRE BODYPUMP™ CLASS FROM TWO SEPARATE STUDIES

	Mean Average Oxygen Consumption (VO_2)	Mean Heart Rate for entire Bodypump™ class	Mean Energy Expenditure for entire Bodypump™ Class
Stanforth, Stanforth and Homeke, 2000 (30 Participants, 15 Male, 15 Female)	14.8 $ml.kg^{-1}.min^{-1}$	123.6 bpm	1113 kJ
Lythe and Pfitzinger, 2003 (10 Participants, 5 Male, 5 Female)	20.24 $ml.kg^{-1}.min^{-1}$	135.4 bpm	1726.2 kJ

joint range of motion, improve core strength, reduce stress levels, and provide a lasting sense of well being, calm and focus. Each class consists of 45 minutes of movement followed by 10 minutes of relaxation and meditation. The class begins with a warm-up comprised of various Tai Chi movements aimed at warming the body and focusing the participant. The next 8 tracks take participants through various yoga and Pilates sequences designed to strengthen key muscle groups. Poses and stretches are used to enhance suppleness and flexibility. (Les Mills International Limited, 2012)

Only two existing research articles specifically mention Bodybalance™. Kahn and Rabia report an increase in maximal lower back strength, increased flexibility around the hip and trunk region and a reduction in anxiety levels following a 12 week participation in regular Bodybalance™ classes. (Khan, Marlow, & Head, 2008) The same study also reports a body fat reduction of 1.1–1.2% for the 17 participants. A second unpublished PhD Thesis by Khan reported no changes in either group for body mass or BMI. (Khan, 2010) Kahn's thesis examines the effect of Bodybalance™ exercise on core stability and back pain, and through the combination of studies, concluded that Bodybalance™ can be regarded as an exercise format that can be beneficial to a healthy population.

Bodybalance™ is comprised of various forms of mind–body exercise such as yoga, Pilates and Tai Chi. Existing data from research of these activities can support outcomes of Bodybalance™ classes.

Yoga forms the majority of the Bodybalance™ class. This ancient Indian practice has become increasingly popular in western society and is one of the top ten most popular sport and recreational activities participated in by women. (Australian Bureau of Statistics, 2011b) Various studies show that yoga can significantly reduce blood pressure and heart rate (Damodaran, Malathi, Patil, Shah, & Marathe, 2002; Jayasinghe, 2004; Ross & Thomas, 2010) and can reduce risk factors for type-two diabetes mellitus, including glucose tolerance, insulin sensitivity and lipid profiles (Innes & Vincent, 2007) and finally, increase maternal comfort and reduce labour time. (Chuntharapat, Petpichetchian, & Hatthakit, 2008) The literature broadly suggests yoga can improve both physical and mental health. (Ross & Thomas, 2010)

A nationwide survey involving 2,597 yoga practitioners in Australia was undertaken by Penman et al. in 2012. (Penman, Cohen, Stevens, & Jackson, 2012) The survey showed that more than half of the respondents practiced yoga more than once per week for an average time of 60–70 minutes, while the mean years of regular practice was 5.62. Respondents were able to select multiple reasons for beginning and continuing yoga practice. The most popular reasons being 'health and fitness'; a rather broad and subjective category, 'increased flexibility/muscle tone'; although this is not defined, and to 'reduce stress and anxiety'. Fifty-three percent of respondents reported that health issues or medical conditions were perceived to be 'much better' since participating in yoga classes. Self assessed health status is important as it is commonly used as a proxy measure of actual health status and can provide insights into how people perceive their own health in relation to lifestyle behaviors or disease. (Australian Bureau of Statistics, 2011a) The results of this study are perceived rather than based on scientific data. One limitation to this study is that participants could be potentially biased, as they are mostly long-term, regular practitioners of yoga.

Pilates is another technique practiced in a Bodybalance™ class. Over the past decade the Pilates method of exercise has become increasingly popular. Pilates mixes the practical movement styles and ideas of gymnastics, martial arts, yoga and dance. (Latey, 2001) The Pilates method was not developed alongside any scientific theory, however as this method has increased in popularity, evidence based research has become available. Research into Pilates has provided a link

between this mode of exercise and improved flexibility, transverse abdominis activation, lumbar-pelvic stability and muscular activity. (Bernardo, 2007) In spite of this, the use of Pilates in other roles such as improved fitness and rehabilitation is yet to be supported through scientific research. (Aladro-Gonzalvo, Machado-Diaz, Moncada-Jimenez, Hernandez-Elizondo, & Araya-Vargas, 2012; Sorosky, Stilp, & Akuthota, 2008)

Aladro-Gonzalvo et al. conducted a literature review on the effect of Pilates exercises on body composition and found seven papers valid for inclusion in the review. Further, within those seven studies, only four males were included for testing (two studies used two males each). The review resulted in a lack of evidence supporting the suggestion that Pilates exercise has a positive effect on body composition. (Aladro-Gonzalvo, et al., 2012) The authors findings are supported by Segal et al. (Segal, Hein, & Basford, 2004) in an observational study of 47 participants finding no changes in lean body mass, or weight. However, Segal et al. did find improvements in trunk flexibility across this group.

Tai Chi forms the warm up of a Bodybalance™ class and is interspersed throughout stretching tracks. Tai Chi Chuan is an ancient Chinese martial art that combines rhythmic movement and self-defense practice with deep breathing, in an attempt to connect mind and body. (Sandlund & Norlander, 2000) Studies show that Tai Chi is effective as a moderate intensity exercise as it does not demand more than 55% of maximal oxygen uptake. (Li, Hong, & Chan, 2001; Sandlund & Norlander, 2000) Tai Chi has been shown to produce an improved blood lipid profile changes over a 12 week intervention (Tsai et al., 2003), as well as reduce blood pressure and improve psychological health. (Sandlund & Norlander, 2000; Wang et al., 2010)

There is considerable research on mind–body techniques when practiced individually, however the design and methodology of these studies have failed substantiate claims pertaining to health and fitness benefits. More research is needed to provide a scientific analysis of these techniques, as well as to evaluate mind–body classes that combine methods and principles from a mix of different modalities.

Bodycombat™ class is a 55-minute cardiovascular workout inspired by martial arts. (Les Mills International Limited, 2012) It draws on techniques from an array of disciplines such as karate, boxing, Taekwondo, Tai Chi and Muay Thai. The class starts with separate upper and lower body warm-up tracks. Participants learn the moves and techniques used throughout the class then move into a series of fight combinations throughout the combat and power training tracks. The conditioning track is a combination of upper body and core work followed by a stretch cool down.

Guglielmo and Ferrari compared heart rate and blood lactate in Bodycombat™ and Bodypump™ in 16 women to determine intensity. (Guglielmo & Ferrari, 2006) Results show that the Bodycombat™ participants demonstrate a higher overall heart rate of 162.4 bpm and 86% of predicted maximal heart rate compared with 125.9 and 61.4%. No significant difference was shown among the mean values of blood lactate between the Bodycombat™and Bodypump™ programs. (Bodycombat™ = 4.27 mM and Bodypump™ = 5.32 mM respectively). The study was also a between-subjects design, meaning that no real comparison could be made between the two classes as they used different subject groups. Due to the low participant numbers (N=9 for Bodypump™ and N=7 for Bodycombat™ respectively), no statistical analysis of the mean values of both groups was determined for comparison. Future research should consider comparing the same participants for each class to make these results more valuable in translation to the fitness industry.

Boxing forms the majority of a Bodycombat™ class. As there is a lack of literature on this program, research on fitness boxing classes will be used

as a proxy measure for Bodycombat™. A study completed in 2003 investigated cardiovascular response to boxing tempo in 18 trained volunteers (12 men and 6 women). (Kravitz, Greene, Burkett, & Wongsathikun, 2003) Participants completed two-minute fitness boxing trials at various tempos. Oxygen uptake, heart rate, ventilation and rate of perceived exertion were taken during each trial. Results show that boxing speed was associated with increased ventilation, heart rate response and perceived effort, but not with VO_2. These results demonstrated that fitness-boxing programs compare favorably with other exercise modalities in cardiovascular response and caloric expenditure. Even though the results of this study give insight into how boxing speed effects cardiovascular response, the speed and tempo of boxing in programs such as Bodycombat™ are controlled by the tempo of the music, and varies from track to track, along with choreography and technique. There is limited amount of literature available on Bodycombat™ classes and fitness boxing classes in general.

Bodyattack™ is a 55 minute high energy class that combines athletic aerobic movements with strength and conditioning exercises. (Les Mills International Limited) According to the LMI website, Bodyattack™ is a 'sports-inspired cardio workout'. (Les Mills International Limited) The class contains a combination of athletic aerobic movements along with strength and conditioning exercises. (Les Mills International Limited, 2012) The first four tracks build up to an intense peak, which is followed by an upper-body conditioning track. Four more cardio tracks follow, which then build up to a second peak. This is followed by a lower body conditioning track, core training, and lastly, a stretch cool-down.

Only one study could be found that has attempted to scientifically analyse a Bodyattack™ class. This study measured caloric expenditure and aerobic demand of four different LMI programs, these being Bodycombat™, Bodyattack™, Bodystep™, and RPM™ (cycling class). (Lythe & Pfitzinger, 2000) It should be noted that this was a non-peer reviewed publication, written with the support of Les Mills International. Lythe and Pfitzinger found that on average, participants in a Bodyattack™ class had a total energy expenditure of 631 (± 103.2) calories per class, the highest of the four classes measured (2000). There are many limitations to this study, the first being the low number of participants. Fifteen subjects in total were used in the study but only six subjects (3 male, 3 female) performed each class meaning there is low statistical power associated with the results. Secondly each class investigated had a different subject group, meaning comparisons between classes were not possible. Thirdly, to allow for gas analysis, arm and leg movements were restricted, which suggests subjects did not exercise at their normal level of intensity. Due to the limitations of this research, it is difficult to use these results as an indication of general population. Research needs to be completed quantifying physiological parameters of a Bodyattack™ class in order to allow exercise professionals to prescribe classes based on scientific results.

Bodyattack™ is the closest Les Mills program to a traditional aerobic dance class as it uses a similar range of movements and tempo. It is reasonable, therefore, to use research extrapolated from aerobic dance classes.

High impact aerobic dance classes consist of a mix of dance style steps combined with jumping, bouncing and plyometric activities, whereas low impact classes aim to achieve the same level of intensity, but contain few movements where the feet leave the floor. Darby et al. assessed physiological effects of aerobic dance exercise with variations of impact, step, arm movement and cadence. (Darby, Browder, & Reeves, 1995) Sixteen female aerobic dance instructors completed three eight-minute trials where four movements were completed. These movements include jumping jack (high impact/more arm movement), a jog (high impact/less arm movement), power jack (low impact/more arm movement) and a march (low impact/less arm movement).

The movements were completed for one minute each at two different cadence levels, 124 bpm and 138 bpm. Metabolic and heart rate data were measured at regular intervals throughout the eight-minute trials. The low impact/more arm movement (power jack) recorded a significantly higher heart rate than the other three movements. The high impact/less arm movement step (jog) was greater than all other movements in absolute VO_2. Both arm movements and the level of impact have different physiological effects on the body. It has been suggested that the type of arm movement may affect heart rate in aerobic dance exercise. (Schaeffer, Darby, Browder, & Reeves, 1995) Darby et al. found that, participants are likely to work at a higher intensity performing whole body movements with less impact, rather than when performing smaller movements using less muscle groups with more impact although this has yet to be supported by other research.

Williford et al. completed a review on the physiological effects of aerobic dance. (Williford, Scharff-Olson, & Blessing, 1989) Although research did vary according to the type and intensity of the class, the authors concluded that if the duration and frequency of participation is increased beyond 30 minutes, three days per week, that aerobic dance should fulfill the ACSM criteria for improving body composition, and will enhance measures of aerobic fitness.

Even though there is a considerable amount of literature available on aerobic dance classes, comparison between studies is difficult as the intensity of a class is heavily dependent on choreography, tempo and instructor delivery.

COMPARISON OF LES MILLS CLASSES

Rixon et al. (2006) estimated energy expenditure on 28 women participating in four different group exercise classes (Bodycombat™, RPM™, Bodypump™ and Bodystep™). The results of this study were compared to the energy expended during different running speed conditions. Energy expenditure was measured using average heart rate values every 15 s throughout the class, The study found that Bodypump™ expended the least amount of calories with 8.0 ± 1.6 kcal.min^{-1}, followed by Bodystep™ with 9.6 ± 1.0 kcal.min^{-1}, Bodycombat™ with 9.7 ± 2.0 kcal.min^{-1}, and RPM™ with 9.9 ± 1.9 kcal.min^{-1}. Results from this study are compared in Table 2 with two different, previously mentioned studies by Lythe and Pfitzinger. (Lythe & Pfitzinger, 2000; 2003)

Both studies used different methods of testing subjects, resulting in several limitations. The restrictive nature of testing to allow for gas analysis in Lythe and Pfitzinger's study meant that movement needed to be restricted, which could have prevented subjects from completing the class at their normal intensity level. Also, the low number of participants may mean that the results from this study are not statistically significant. Rixon, Rehor and Bemben (2006) used heart rate and prediction equations as a means to estimate energy expenditure, which can be inaccurate and has not been validated as a means of

TABLE 2: COMPARISON OF CALORIES PER MINUTE EXPENDED IN FOUR DIFFERENT CLASSES FROM THREE SEPARATE STUDIES

	Rixon, Rehor and Bemben (2006) (kcal.min^{-1})	Lythe and Pfitzinger (2000, 2003) (kcal.min^{-1})
Bodypump™	8.0 ± 1.6	7.2 ± 1.6 (Lythe & Pfitzinger, 2003)
Bodystep™	9.6 ± 1.0	10.2 ± 1.1 (Lythe & Pfitzinger, 2000)
Bodycombat™	9.7 ± 2.0	10.4 ± 1.8 (Lythe & Pfitzinger, 2000)
RPM™	9.9 ± 1.9	12.8 ± 1.9 (Lythe & Pfitzinger, 2000)

measuring energy expenditure in aerobic dance. This has been acknowledged by the authors. (Rixon, et al., 2006)

Gottschall et al. (Gottschall, Jones, Mills, & Hastings, 2011) recently conducted a longitudinal intervention out of Penn State University, taking 32 untrained individuals through a 30 week training program. The unpublished results of this study were written with the consent of LMI. Subjects combined two Bodypump™ classes with their choice of four cardio classes (Bodyattack™, Bodystep™, Bodycombat™ and RPM™) and a combined yoga/Pilates/Tai Chi class, Body balance™. This activity level aligns with the current American College of Sports Medicine guidelines for healthy adults: 60 minutes of cardiovascular activity three to five days per week, as well as eight to ten muscular strength and flexibility exercises two days per week. (American College of Sports Medicine, 2012)

The 30 week program resulted in statistically significant decreases in body weight, body fat percentage, trunk fat percentage, total cholesterol concentration, low-density lipoprotein cholesterol concentration, triglycerides and diastolic blood pressure, along with statistically significant increases in cardio respiratory fitness, high-density lipoprotein cholesterol concentration and lean mass percentage. This study successfully recorded long-term benefits of participating in a combination of popular group exercise classes. However it could be argued that the findings recorded are to be expected from a group of untrained individuals that have started regular exercise, regardless of the type of program they have undertaken.

Further research is required to investigate methods of assessing and comparing basic physiological measures for each popular Les Mills program. This will allow researchers to analyse and compare classes in detail to gain a better understanding of the programs as a whole and contribute to continuous improvement of these programs.

The next section of this literature review looks at ways in which group exercise or sport has been measured in the past as well as addressing new technologies available. These may be more accurate, less restrictive, and measure more physiological parameters and movement patterns than past methods.

CURRENT METHODS USED TO MEASURE GROUP EXERCISE CLASSES

Rate of perceived exertion

Using rate of perceived exertion scales is a proven method of measuring and communicating exercise intensity as well as other parameters such as pain, or discomfort. Perceived exertion is the ability to judge the intensity or perception of effort of an exercise and is measured using rating scales. The most widely used instrument to measure exercise intensity is Borg's rating of perceived exertion (RPE) scale. (Chen, Fan, & Moe, 2002) This 15-category scale rates perceived exertion from six (no exertion at all) to 20 (maximal exertion). This scale has been validated for use in many different sports and research has found that there is a linear relationship between heart rate and oxygen uptake during exercise such as rowing and cycling. (Little & Williams, 2007; Marriott & Lamb, 1996)

Literature on perceived exertion in relation to actual exertion in aerobic dance classes is conflicting. Shaeffer et al. (Schaeffer-Gerschutz, Darby, & Browder, 2000) investigated RPE and physiological responses during aerobic steps by impact and type of arm movement. Subjects performed different steps with varying levels of impact and arm movement and RPE, VO_2 max and heart rate were recorded. The results show that changes in overall RPE for the steps of varying intensity changed proportionately to heart rate and VO_2. These findings have not been supported in other studies. Shaeffer et al. (1995) and Ozkan and Kin-Isler (2007) found that correlations between RPE and other metabolic variables

in aerobic dance and step aerobics classes are not significant. This suggests more research needs to be undertaken on specific steps, arm movements and levels of impact of aerobic dance style classes to determine if a relationship exists between intensity during aerobic dance classes and RPE and what factors influence the relationship.

Bartholomew and Miller completed a study on 204 women investigating the impact of perceived performance in response to an aerobic dance class. (Bartholomew & Miller, 2002) Participants participated in a self-selected aerobic dance class and asked questions relating to psychological state prior to the class and at five and ten minutes post participation. Rate of perceived exertion for the entire class was also taken at five minutes post participation using the Borg 9-20 RPE. Although exercise intensity was not controlled during the study, significant positive correlations were found between ratings of performance RPE and feelings of enjoyment and effort.

Research has found that these positive feelings can lead to increased participation and adherence to exercise programs. Koltyn and Morgan (1992) investigated the efficacy of perceptual versus heart rate monitoring in the development of endurance over a 14 week course. Subjects were divided into two groups, 38 used heart rate and 38 subjects used RPE to monitor exercise intensity. Although both groups increased endurance significantly over the 14 week period, RPE was associated with greater improvement in endurance than heart rate monitoring. One possible reason for this, as indicated by the authors and Borg (1982) is that RPE is comprised of many inputs and can be a more accurate indicator of strain than any single measure.

Pedometers

Pedometers have been used to count the total number of steps and are low cost and simple to use making them accessible to the average person exercising. (Beets & Pitetti, 2011; Kumahara, Tanaka, & Schutz, 2009; Tudor-Locke, Williams, Reis, & Pluto, 2004) Pedometers are not only useful measurement tools, they have also been found to help motivate sedentary people increase their daily activity level. (Gardner & Campagna, 2011; Tudor-Locke, 2002)

Traditionally, a pedometer could only indicate total movement count and could not monitor exercise intensity. New technological advancements now allow pedometers to monitor moderate to vigorous physical activity via step frequency. (Beets & Pitetti, 2011) Beets and Pitetti proposed a means of measuring exercise intensity for youths with an intellectual disability by using pedometers and heart rate monitors based on the concept that step frequency is related to exercise intensity. (Beets & Pitetti, 2011) Although, the authors did not take into account height and weight of participants, the results the study demonstrated that on average 122 steps.min^{-1} met the minimum threshold for moderate to vigorous activity. This study shows that the combination of heart rate monitors and step count per minute could help establish guidelines for exercise intensity that are easy to measure, and cost effective for general populations. Even though the level of participation in group exercise classes in Australia is considerable, there is currently no found research that determines how different types of group fitness classes can contribute to participants daily step count.

Heart rate monitors

Heart rate monitoring is a widely used means of monitoring exercise intensity in a variety of sports and activities. Heart rate monitors are mainly used to determine exercise intensity and indirectly measure energy expenditure. However, factors such as hydration levels, ambient temperature (Achten & Jeukendrup, 2003), diet and caffeine intake (Smith, 2002) have been shown to have a profound effect on heart rate. Under controlled circumstances and with prudent application, heart rate monitoring can be used in conjunction with other methods to measure energy expenditure. (Ceesay et al., 1989)

Consensus has not been reached regarding using heart rate to provide an estimation of energy expenditure in group exercise classes, particularly modes of group exercise that involve vigorous arm movements. Bell and Bassey compared oxygen uptake and heart rate in low and high impact aerobic dance classes on ten women and found that neither arm work, nor the level of impact of the class effected the normal linear relationship between heart rate and oxygen uptake. (Bell & Bassey, 1994) In contrast, Olson et al., in their study of eleven women, in their results found that heart rate must be approximately 80% of the predicted heart rate max or greater to produce a response in excess of 50% of VO_2max. (Scharff-Olson, Williford, & Smith, 1992) Thus suggesting that a direct relationship between heart rate and oxygen consumption may not exist. These conflicting findings could be explained by the differences in fitness levels of participants of the two subject groups, and also the low subject numbers in both studies.

Combined heart rate and movement sensing technology can offer greater precision in measuring physical activity then either method used independently. (Avons, Garthwaite, Davies, Murgatroyd, & James, 1988; Brage et al., 2006; Chen, Janz, Zhu, & Brychta, 2012; Kumahara et al., 2009; Rennie, Rowsell, Jebb, Holburn, & Wareham, 2000)

Accelerometers

Movement sensors can be used to measure human physical activity and are suitable for use in real life conditions as they provide a cost effective, non-invasive and objective measurement of physical activity with minimal hindrance to the participant. (Kumahara et al., 2009; Rowlands & Eston, 2005) Examples of these wearable sensors include electromechanical switches, mercury switches, pedometers, inclinometers, gyroscopes and goniometers, accelerometers, and global positioning systems (GPS). (Chen et al., 2012) Accelerometers are considered the most widely used sensors for the assessment of physical activity as they can objectively assess activity patterns, and indirectly predict energy expenditure using internal algorithms. A uniaxial accelerometer measures acceleration and deceleration in the vertical plane, whereas biaxial and tri-axial accelerometers are sensitive to movement in multiple planes. Accelerometers are ideal for answering questions regarding patterns of physical activity as they measure movement in multiple directions and can be used as a measure of frequency and intensity. (Coleman et al., 1999) Currently, micro-electromechanical system tri-axial accelerometers are considered to be the principal class of motion-detecting transducers. (Chen et al., 2012) A key consideration in accelerometer use is the placement of sensors on the body, which are determined by the researcher based on the type of movement being analysed. For example, when measuring kick rate in swimming, sensors were placed on the thigh and shank. (Fulton, Burkett, & Pyne, 2009) To gain accurate physical activity measurement in-group fitness, movement sensors would need to be located on the part of the body that best indicates overall activity. Best practices regarding placement of sensors for group exercise classes has not been determined by the literature.

Multi sensor devices – The BodyMedia SenseWear MF-SW Armband

Methods used to measure physical activity in previous studies have been generally effective in generating results for group exercise classes either as a whole or for specific steps in classes. Thus far they have not managed to look at all aspects of physical activity in the class, or break classes down to different segments and tracks for a more detailed analysis of the entire workout. Emerging technologies such as the BodyMedia SenseWear MF-SW Armband (SWA) measures physical activity and movement data from a tri-axial accelerometer along with other physiological sensors (skin temperature, heat exchange and galvanic skin

response). The SWA uses information from the combination of sensors to provide estimates of energy expenditure. An advantage of the multi sensor technology with the inclusion of thermal sensors is that this combination of sensors can provide increased sensitivity for detecting subtle changes in energy expenditure associated with complex movements. The wireless monitor is worn on the upper arm over the triceps muscle and is lightweight and comfortable to wear.

There is a wide range of literature validating the SWA as a tool for assessing physical activity in free-living adults. (Arvidsson, Slinde, & Hulthen, 2009; Berntsen et al., 2010; Dwyer, Alison, McKeough, Elkins, & Bye, 2009) However, results from studies investigating the accuracy of the SWA in measuring energy expenditure at high intensities are conflicting. Drenowatz and Eisenmann (2011) conducted research with 20 (10 male, 10 female) endurance trained subjects who all performed three trials of 10 minute treadmill runs at varied intensities as well as a 30 minute run at their own pace. SenseWear armbands predicted energy expenditure accurately up to 10 METS and underestimated energy expenditure during very vigorous exercise (above 10 METS).

To date, only one study has been found investigating the use of SWA in group exercise classes. Sharpenstein et al. (Sharpenstein, 2007) evaluated the ability of the SWA to estimate energy expenditure of a commercially available yoga video with 25 subjects (12 males and 13 females). Results were then compared to indirect calorimetry. Results show that there were no significant differences between the SWA and indirect calirometry in overall energy expenditure therefore validating the use of the SWA for predicting energy expenditure during yoga exercise.

Johannsen et al. (2010) completed a study in 2010 that measured the accuracy of armband monitors for measuring daily energy expenditure on 30 adults aged from 24–60 years using the Double Labeled Water Technique (DLW) as the criterion measure of total energy expenditure. The results showed that the SWA performed similar or better than other available monitors, supporting the use of these monitors as devices to measure group exercise classes. This research, along with several others (Benito et al., 2012; Drenowatz & Eisenmann, 2011), have also measured total daily energy expenditure which may also be of value in comparing the value of the different group exercise classes.

A comparison study of activity monitors to estimate the energy cost of treadmill exercise was completed in 2004 by King et al. (King, Torres, Potter, Brooks, & Coleman, 2004) Subjects were required to walk at various treadmill speeds wearing five different movement sensors, simultaneous movement measures and indirect calorimetry. The SWA produced the most accurate results with subjects walking at speeds of 118 $m.min^{-1}$ and 214 $m.min^{-1}$, the highest speeds taken. Authors also suggested that issues surrounding belt mounted movement sensors such as the inability to detect arm movements and external work performed by lifting pushing and carrying objects may be avoided by SenseWear Armband as they incorporate both heat sensor technology and are placed on the upper arm. Since this study was published the SenseWear Armband along with its algorithms have been updated further improving accuracy. (King et al., 2004)

CONCLUSION

Les Mills programs are used world wide, given the level of participation in these classes in Australia and around the world and their contribution to the ongoing growth of the Australian fitness industry, there is a distinct paucity of research investigating benefits of popular modern group exercise programs and LMI programs in particular which are the world's most popular group exercise programs.

There is an extensive amount of literature available exploring the benefits of more estab-

lished techniques such as yoga, Tai Chi, Pilates and even dance style aerobics. However, when these styles of exercise are combined, or modernised with new techniques or equipment, the scope of literature is imited. The value of the research available is restricted by inconsistencies in the type of equipment used, participants fitness level, variation in class structure, instructor delivery and the inability to measure a group fitness class as it is intended, without being restricted by testing equipment. Considering the level of participation in these classes it is important that a form of measurement is used that provides greater accuracy and consistency.

It is important that exercise professionals and participants better understand the physiological influence of these classes and whether participants are actually experiencing the benefits promoted from different types of group exercise classes. This would assist both exercise professionals and group exercise participants in choosing a class related to their fitness goals and potentially increase their success in achieving those goals

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