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# Physical Activity and the Nintendo Wii: A Psycho-Physiological Approach

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**Abstract**

Purpose. This study examined whether the affective responses pre-, mid- and post- a single bout of Interactive Video Game Technology (IVGT), as well as the amount of energy expended, were comparable to those experienced during traditional physical activity.

Methods. The randomised cross-over design saw each participant (n = 16 undergraduate students) engage in 30-minutes of Nintendo Wii ™ Tennis and 30-minutes of Hardcourt Tennis. Measurements of affect were taken pre-, mid- and post-activity, and estimates of energy expenditure calculated. Two post-experiment focus group interviews were also used to explore participants' affective responses.

Results. Repeated measures analyses of variance revealed both valence and activation to be higher during Hardcourt Tennis at all time intervals. A paired t-test also indicated that energy expenditure was greater during Hardcourt Tennis. However, the IVGT condition was still associated with low-activation pleasant affect. The interview data supported and partially explained the quantitative findings from a self-determination perspective.

Conclusions. These findings demonstrate that traditional physical activity elicits greater psycho-physiological benefits than IVGT physical activity.

Applications. The efficacy of IVGT-based physical activity may reside in its ability to operate as a motivational entry point for inactive populations, making the initial process of physical activity an enjoyable means to displace sedentary behaviour.

**Introduction**

Physical inactivity remains a prevalent issue within the United Kingdom (UK). Indeed, almost half of the UKs population fail to meet the recommended levels of physical activity (Department of Health, Physical Activity, Health Improvement and Protection, 2011). Whilst some individuals fail to even contemplate the enactment of physical activity, exercise or sport, others experience the prospect of these health behaviours in conjunction with an awareness of real or perceived barriers to

participation (Trost et al., 2002; Biddle et al., 2011). In turn, individuals are either inattentive to the opportunities for, or often discouraged from engaging in traditional modes of physical activity (Biddle and Mutrie, 2008). As a result, many such individuals are more receptive to activities of a sedentary nature, such as watching television and playing video games (Biddle et al., 2011). However, as a consequence of the technological developments within the video gaming industry, researchers and practitioners have begun to capitalise upon the inherent appeal of video games as a way to counteract inactive screen time (Foley and Maddison, 2010).

Interactive Video Game Technology (IVGT), otherwise known as "exergaming" or "active video games", are the latest generation of consoles that permit an interface between a player's physical movements and the video game activity. In particular, the Nintendo Wii ™ console consists of a wireless and motion-sensitive hand-held remote that measures a player's acceleration of movement in three-dimensions. This movement is then transmitted into the virtual environment. Although IVGTs are not without the risk of musculoskeletal injury (Sparks et al., 2009), research has consistently documented IVGTs to increase energy expenditure over and above traditional video games that are of an inactive nature (Biddiss and Irwin, 2010; Foley and Maddison, 2010). However, whilst the literature is clear that IVGTs should not replace traditional physical activity, there is a lack of consensus concerning the intensity of physical activity derived from these new generation video game consoles, and whether it is substantial enough to contribute to the weekly levels of physical activity recommended by the government (Graves et al., 2008; Porcari et al., 2008; Miyachi et al., 2010).

There is also a paucity of research concerning participant's affective responses to IVGTs. This is somewhat surprising when it is considered that emotions, moods, and affect play an influential role in the re-enactment of behaviours (Biddle and Mutrie, 2008), and are indicative of psychological well-being (Wilson and Rodgers, 2007). Indeed, from a hierarchical perspective of the affective domain, emotions are found at the most specific level of the hierarchy (i.e., joy, happiness, fear), and are characteristically intense yet short-lived; whereby they are experienced in response to an event or appraisal (Ekkekakis and Petruzzello, 2000). Alternatively, moods are regarded as global feeling states (i.e., cheerfulness, depression, energetic) that are typically non-specific, yet persist for longer periods of time compared with emotions. Finally, basic affect is the most general, broad and irreducible construct within the affective domain, and is "the core of the subjective experience that accompanies all valenced (positive or negative) responses" (Ekkekakis and Petruzzello, 2002, p.36). Thus, basic affect is present in all moods and emotions. An individual's psychological state can therefore be determined according to its basic affective quality at any moment.

With regards to physical activity, affective experiences are both an outcome and a determinant of behaviour (Biddle and Mutrie, 2008). Hence, when physical activity produces pleasantly valanced affective responses, future participation in such health behaviours can be expected (Russell and Newton, 2008). Unfortunately, however, there are various aspects of physical activity that lend themselves to undesirable affective responses, which can become a deterrent to the initiation and maintenance of a physically active lifestyle. For example, the exertion perceived during physical activity can be interpreted as painful and unpleasant, whilst the non-hedonistic nature of physical activity can lead people to conclude their involvement to be both tedious and unrewarding (Biddle and Mutrie, 2008). In contrast, video games are typically pleasurable pursuits, often performed for the purpose of fun, and result in immediate gratification (Russell, 2009). In particular, the Nintendo Wii ™ is advertised as "…a radical step into a new era of entertainment…maximising the fun and minimising the fuss" (Nintendo, 2010). Through the coupling of physical movement with such an inherently enjoyable pastime, IVGTs have the potential to

make the initial process of being physically active conducive to pleasant affective states (Russell, 2009). Such exposure to the pleasurable and intrinsically motivating properties of physical activity should be a salient objective of interventions seeking to engage inactive and sedentary populations in more active lifestyles (Biddle and Mutrie, 2008).

The limited number of research studies that have examined participants' affective responses to IVGTs have also produced promising results. More specifically, Russell and Newton (2008) recorded changes in mood at three time intervals (pre-, post-, and 10 minutes post-condition) among 168 university students (mean 21.51 years) who were assigned to one of three 30-minute experimental conditions (IVGT, a sedentary video game, or cycling). Results indicated more favourable mood responses among participants exposed to the IVGT or cycling condition, compared with participants in the video-only condition. Yet, no significant differences in mood responses were detected between IVGT and cycling participants. However, the use of an impractical form of IVGT (Sony Playstation 2 connected to a bicycle ergometer that controlled Smuggler's Run) may have diminished the ecological validity of the study's results. Indeed, many families would find it difficult or impossible to finance and/or cater for such an IVGT within their living space. Russell and Newton (2008) also failed to standardise the two-player (paired) format in which all participants were intended to perform their assigned condition. Consequently, the potentially differing motivational/competitive climates fostered (Vazou et al., 2006) might have confounded the affective responses recorded.

Russell and Newton (2008) also measured their participants' affective responses through the use of the positive and negative affect schedule (PANAS) (Watson et al., 1988). Although psychometrically sound and theoretically grounded, the PANAS measures the affective construct of mood (Watson and Tellegen, 1985). However, given that the literature pertaining to the affective responses to IVGTs is still in its infancy, it is necessary to begin with an examination of the most fundamental construct (i.e., basic affect) within the affective hierarchy (Ekkekakis and Petruzzello, 2000). Should researchers attempt to document isolated mood states and specific emotions before sufficient evidence has been accumulated at a broader level, important shifts in the affective responses to IVGTs could be overlooked. In particular, Ekkekakis and Petruzzello (2002) criticise the ability of the PANAS to adequately measure affectivity; whereby items are based upon pre-determined adjectives that bias scores towards affective states containing high (as opposed to low) levels of arousal, resulting in the exclusion of one half of the possible affective space. In addition, the administration of the PANAS is of an intrusive nature to participants' engagement with physical activity. Hence, Russell and Newton (2008) were restricted to the collection of affective data pre- and post- their experimental conditions. In the absence of knowledge regarding participants' in-task affective experiences, meaningful fluctuations in valence and arousal are dismissed, which could lead to incomplete conclusions about the psychological impact of physical activity and/or exercise environments (Ekkekakis, 2003; Ekkekakis et al., 2008).

Interestingly, Legrand et al., (2011) compared in-task affective valance scores from three 10-minute conditions (exercise-only, self-selected IVGT, and externally imposed IVGT) using the Self-Assessment Manikin (Lang, 1980). Results indicated that participants who were able to self-select between two types of IVGTs had more pleasantly valanced affective scores, compared to participants from the experimenter-imposed IVGT and exercise-only conditions. However, whilst the researchers included a feasible form of IVGT (Wii fit ™), it was performed whilst running on a treadmill rather than whilst running on the spot; the latter of which represents how the IVGT would be performed within the home environment. Legrand et al., (2011) also failed to measure perceived activation, again resulting in the measurement of only one half (i.e., pleasure/valence) of the possible affective space.

Given that many individuals fail to undertake physical activity regularly enough to gain the concomitant psycho-physiological health benefits, and that a multitude of barriers (both perceived and real) exist to physical activity, it seems pertinent to explore other avenues through which people can become more physically active. Therefore, the purpose of the present study was to further the work of Russell and Newton (2008) and Legrand et al., (2011) in order to examine whether the affective responses pre-, mid- and post- a single bout of IVGT were comparable to those experienced in conjunction with more traditional physical activity. The present study also sought to provide participants with the opportunity to clarify their experiences related to IVGTs, and to detail the variables influencing their affective responses. In addition, the present study sought to examine the amount of energy expended during IVGT against energy expenditure during more traditional physical activity. It was hypothesised that the affective responses and amount of energy expended during more traditional physical activity would be significantly higher than that of IVGT.

## Methods

### Participants

A total of 16 final year undergraduate students (n = 11 males, n = 5 females, mean age 21.56, s = 1.15 years, mean height 1.73, s = 0.10 metres, mean weight 74.69, s = 10.64 kilograms) volunteered to participate in the study. This sample was chosen because of the well documented (e.g., Pinto and Marcus, 1995; Pinto et al., 1998; Leslie et al., 1999) decline in physical activity levels post-adolescence. In addition, Dishman (1994) and Leslie et al., (2001) stated that physical activity levels during the young adult years are likely to have an important influence on habitual physical activity levels in overall adult life. The research protocol was explained to the participants and written informed consent obtained. Ethical approval was also obtained from the University of the first author prior to data collection.

### Design

The randomised cross-over design saw each participant engage in a 30-minute bout of IVGT (Nintendo Wii ™ Tennis; WT) and a 30-minute bout of traditional physical activity (Hardcourt Tennis; HT) on the same day, with a 15-minute break between each activity. However, in an attempt to maximise the ecological validity of the experimental design, the bout of WT was performed indoors in a lecture room, where the relative humidity (%) and temperature (°C) were 34% and 18.8°C, respectively; whereas the bout of HT was performed outside on a tennis court, where the relative humidity (%) and temperature (°C) were 36% and 18.9°C, respectively. Measurements of affect were taken pre-, mid- and post-activity and energy expenditure was estimated from heart rate, age, weight and sex. Two post-experiment semi-structured focus group interviews were then conducted with eight participants in each group.

### Measures

The Circumplex Model of Affect. Derived from the Emotional Circumplex (Russell, 1980), the Circumplex Model has been forwarded by Ekkekakis and Petruzzello (2002, 2008) as a theoretically sound and empirically supported measure of basic affect. The model is composed of two bipolar and orthogonal dimensions, along which basic affect can be placed, in order to provide a broad and parsimonious picture of the affective experience. The valance (hedonic tone) dimension is polarised from pleasure-to-displeasure, whilst the activation (arousal) dimension extends from low-to-high. Ekkekakis and Petruzzello (2002) suggest that the division of the Circumplex Model into quadrants produces four variants of affective experience: high-activation pleasant affect (e.g., excitement), high-activation unpleasant affect (e.g., distress), low-activation pleasant affect (e.g., calmness), and low-activation unpleasant affect (e.g., boredom).

In the present study, activation and valance were assessed by two self-report scales: the Felt Arousal Scale (FAS) of the Telic State Measure (Svebak and Murgatroyd, 1985) and the Feeling Scale (FS; Hardy and Rejeski, 1989), respectively. The FAS is a six-point, single item scale, that is anchored from 1 (low arousal) to 6 (high arousal). Conversely, the FS is an 11-point single-item bipolar measure of pleasure-displeasure, with a scale that ranges from +5 (very good) to -5 (very bad). Together, the FAS and FS provided a quick and reliable assessment of basic affect pre-, mid-, and post- physical activity.

Energy Expenditure. The prediction equation of Keytel et al., (2005) was used to estimate energy expenditure during both WT and HT. This mixed model of energy expenditure takes into account participants' age, sex, weight, and heart rate. Therefore, a Suunto Team Pack Heart Rate System (Finland) was used to attain measurements of minute-to-minute heart rate throughout the two 30-minute conditions. The correlation coefficient (r) produced by the study sample in Keytel et al., (2005) was 0.857. Hence, the model could explain 73.4% of the variation in measured energy expenditure. In addition, the correlation coefficient of the validation sample in Keytel et al., (2005) was 0.77; suggesting that energy expenditure may be accurately predicted in a group of individuals varying widely in age, fitness, and morphology, without the need for individual calibration.

**Procedure**

Participants were contacted in advance to schedule a time for their participation, to instruct them of the proper attire for the conditions, and to remind them to refrain from physical activity on the day of the experiment. Upon their arrival, participants also completed a Demographic Questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q). Four research associates were responsible for the collection of data, and used standard anthropometric techniques to measure participants' height and weight. Participants were then fitted with a heart rate monitor, so that both resting and in session heart rate changes could be monitored every five seconds in real time, and subsequently downloaded for analysis.

Resting heart rate and basic affect (pre-test) were recorded approximately 15 minutes prior to the familiarisation trials. Here, the research associates held a clipboard displaying the FS and FAS scales in front of the participants, who responded by pointing to the appropriate integer. The familiarisation trials then served as a means to induct participants into the procedures of the conditions, and to control for any initial differences in their experiences of playing the Nintendo Wii ™ console and HT. Participants then began their designated experimental condition. In the WT condition, the game was displayed on a television monitor placed three-feet directly in front of them, and participants were instructed to select the four-player format from the main menu. Foley and Maddison (2010) advocate multi-player formats as an effective means to maintain interest in IVGTs. In the HT condition, participants were provided with a tennis racket (Head ™) and a tube of tennis balls (Wilson ™). However, in both conditions, once a game or match had been completed, participants restarted the event, and continued to play for 30 minutes. All trials were conducted in groups of four participants.

15 minutes into each condition, a second assessment of basic affect (mid-point) was administered. However, throughout the testing procedures, any further interaction between the research associates and participants was kept to a minimum. The research associates also remained mostly out of sight, except when it was necessary to complete the assessments, or to provide assistance to the participants. Once the conditions were completed, post-test basic affect was obtained, and all participants were asked to attend one of two focus group interviews that were scheduled to take place in the following two days. The focus group interviews were conducted by the second author, with the use of a standardised interview guide (Maykut and Morehouse, 1994), and lasted between 30-45 minutes.

**Data Analysis**

Quantitative Data Analysis. Two x two-way repeated measures ANOVAs were used to examine the impact of the conditions (WT and HT) on (a) valence, and (b) activation, across the various time intervals (i.e., pre-, mid- and post-activity). A paired samples t-test was then used to compare the predicted energy expenditure between the two conditions. Effect size was measured by the partial eta squared ($h^2$) method. Clark-Carter (1997) proposed that effect sizes of between 0.001-0.058 were classified as small, 0.059-0.137 were classified as medium, and 0.138 and above were classified as large. Statistical significance was set at $p < 0.05$, and all analyses were computed using the Statistical Package for Social Sciences (SPSS v 16).

Qualitative Data Analysis. The two focus group interviews were transcribed verbatim and then read and re-read by the second author. An initial discovery sheet was then used to identify any recurring words, concepts and/or ideas that emerged from the raw data. This lead to the development of several higher-order themes (Maykut and Morehouse, 1994). The interview transcripts were then re-examined in order to establish whether any other data should be considered under each of the higher-order themes (e.g., as sub-themes), or whether any new higher-order themes needed to be created. Once no new higher-order or sub-themes emerged from the data, it was assumed that the analysis was complete. However, in order to examine for researcher bias, the second author's interpretations were also reviewed, discussed and critiqued by two additional authors until an agreed thematic structure was achieved (Gratton and Jones, 2004).

**Results**

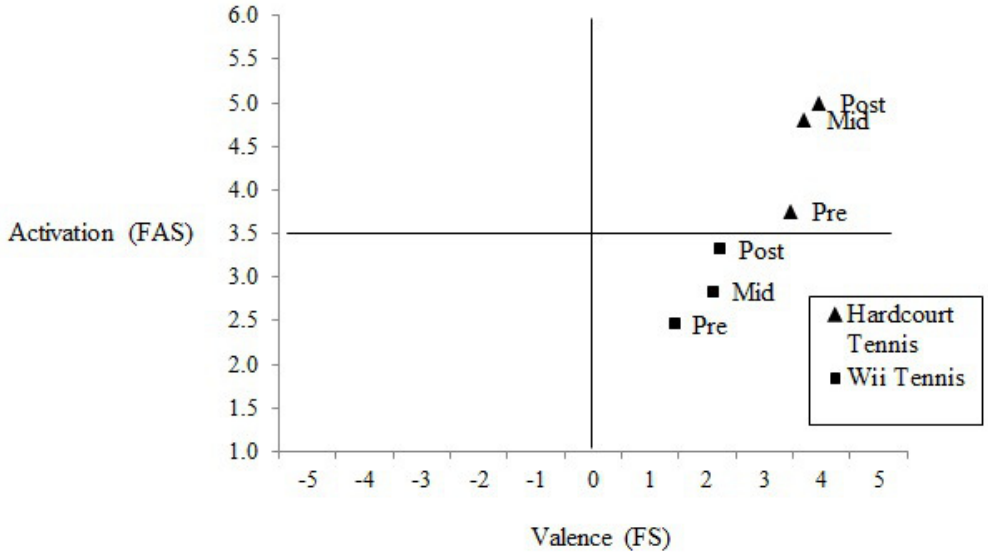
The following section details the results pertaining to the quantitative data for valence, activation, and energy expenditure, followed by the qualitative results from the thematic analysis of the focus group interview data. The mean affective responses pre-, mid-, and post- the WT and HT conditions are displayed on the affective circumplex (Figure 1). The amount of energy expended during the WT and HT conditions is then depicted in Figure 2, and the results from the thematic analysis are presented in Table 1.

**Valence**

The two-way repeated measures ANOVA revealed a significant main effect for condition ($F_{(1, 15)} = 118.389$, $p < 0.0005$, $h^2 = 0.888$), but no significant differences across time ($F_{(2, 30)} = 2.936$, $p = 0.068$, $h^2 = 0.164$), and no condition by time interaction effect ($F_{(1.137, 17.052)} = 0.244$, $p = 0.658$, $h^2 = 0.016$ Greenhouse-Geisser). In line with these results, the mean scores would also appear to suggest that the valence experienced during HT was higher (and therefore more pleasant) than that during WT at all time intervals. However, there was also a trend for valence to increase as each activity progressed.

**Activation**

The two-way repeated measures ANOVA revealed a significant main effect for condition ($F_{(1, 15)} = 53.571$, $p < 0.0005$, $h^2 = 0.781$) and time ($F_{(1.306, 19.586)} = 14.213$, $p = 0.001$, $h^2 = 0.487$ Greenhouse-Geisser), but no condition by time interaction effect ($F_{(1.358, 20.376)} = 1.062$, $p = 0.338$, $h^2 = 0.066$ Greenhouse-Geisser). Bonferroni follow-up tests identified a significant difference between the levels of activation experienced pre- and mid- ($p < 0.0005$) and pre- and post- ($p < 0.0005$) HT. Consistent with the results for valence, the mean scores for activation suggest that the levels of activation experienced during HT were higher than that during WT at all time intervals, and that activation increased as each activity progressed.

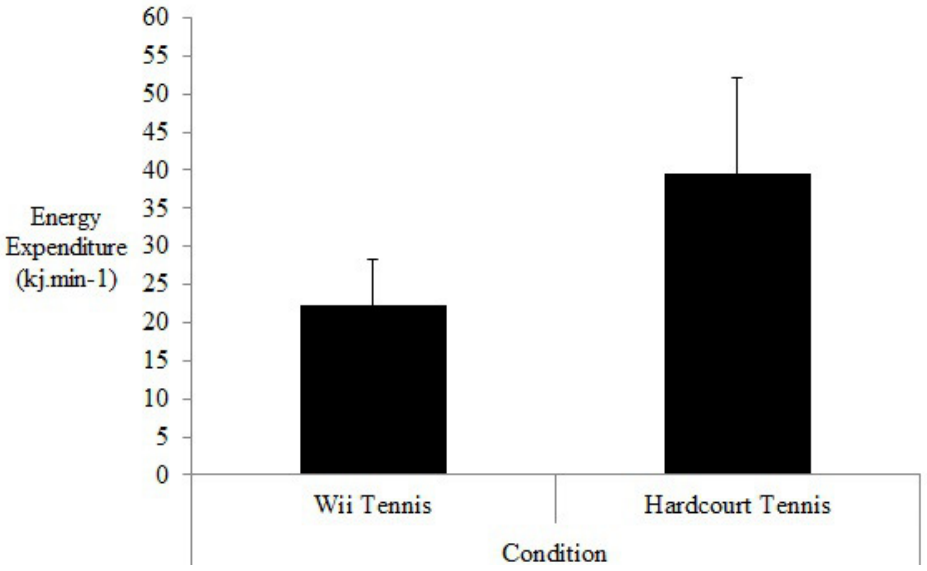



(http://i1.wp.com/thesportjournal.org/wp-content/uploads/2014/06/Figure-1.jpg)

Figure 1. Mean affective responses to Wii Tennis and Hardcourt Tennis, pre-, mid- and post-activity.

**Energy Expenditure**

The paired samples t-test ($t_{15} = 6.853$, $p < 0.0005$) indicated that energy expenditure when playing 30 minutes of HT was significantly greater than when playing 30 minutes of WT.




(http://i2.wp.com/thesportjournal.org/wp-content/uploads/2014/06/Figure-2.jpg)

Figure 2. Mean (s) energy expenditure during Wii Tennis and Hardcourt Tennis.

**Focus Group Themes**

Three higher-order themes (affective experience, influential factors, and perceived exertion) were constructed, with each being composed of several sub-themes.

Table 1. Higher-order and sub-themes derived from the focus group interview data.

| Affective Experience | Influential Factors | Perceived Exertion |
|---|---|---|
| Mood | Weather Conditions | Energy Expenditure |
| Condition Preference | Salience of Competition | Multi-Player Format |
| | Wii Repetitiveness | Effort |
| | Perceived Control | Impact of Enjoyment |
| | Order Effects | |

(http://i2.wp.com/thesportjournal.org/wp-content/uploads/2014/06/Capture5.jpg)

Affective Experience

The participants described their mood during the study and made comments regarding their condition preference. More specifically, high levels of enjoyment were reported, and the participants felt their mood was "quite good" throughout both conditions, which was evidenced by frequent laughing, and being in a playful or carefree state of mind. However, their affective experiences were deemed to have been "better" (i.e., more pleasant) during the HT condition, compared with the WT condition. Furthermore, as the HT condition progressed, participants recalled increasing levels of enjoyment, whereas decreasing levels of affective arousal were experienced as the WT condition progressed. Indeed, one participant stated that: "The longer you did it [WT condition] the more sort of your arousal levels of your mood went down, whereas outdoors [HT condition] the longer you did it for, I think the more I enjoyed it…" Although one participant felt no greater preference for either condition, the majority of participants agreed they had a greater preference for the HT condition.

Influential Factors

In an attempt to explain their affective experiences, the participants detailed several factors that facilitated and/or hindered their levels of enjoyment. Indeed, the weather conditions would appear to have played an important role in the extent to which they enjoyed and preferred the HT condition. For some participants, the dry and warm weather conditions on the day of the experiment made the HT condition more conducive to higher levels of enjoyment. There was also a belief that if the weather conditions had been poor (i.e., wet and cold), they would have felt less inclined to engage in HT and, instead, had a greater preference for the WT condition. More specifically, one participant stated that: "…I think we probably wouldn't have enjoyed it as much if it had been pouring with rain, or was… freezing cold…"

Participants also spoke about the salience of competition, whereby their enjoyment was facilitated by the presence of a competitive atmosphere and a desire to win, both of which were perceived to have been more evident during the HT condition:

You wanna win, I think, I think you're waiting for the shots to come to you so you can really give it a go, you know to sort of score the next point or something, maybe you're wanting to play whereas on the Wii, I wasn't bothered, I genuinely wasn't bothered.

Furthermore, one participant mentioned: "Once we started winning [in the WT condition] it was just too easy", suggesting that a lack of challenge during the WT condition from their opponents had hindered their levels of enjoyment.

The repetitive nature of the Wii was an additional factor that inhibited the participants' levels of enjoyment. Indeed, the novelty of the technology quickly dissipated. Thus, reducing the extent to which they found the WT condition fun. Interestingly, one participant implied that when playing the Nintendo Wii ™ in their leisure time, they would have the freedom to select different games, and this subsequently helped to maintain their interest.

The extent to which participants' perceived themselves to have control over their performance also influenced their perceptions of achievement and affective experience. In relation to the WT condition, participants complained about the inaccuracy between their physical movements and the virtual reality, which resulted in a lack of perceived control over their Wii performance. More specifically, one participant stated that: "It's hard, you can't aim either, you can't sort of direct your shot, you just literally have to just flap your arm about and it can go anywhere and you have no idea where it goes". Participants also became frustrated by the lack of impact their efforts had upon the type, direction and quality of the intended shot. Hence, they concluded that any success during the WT condition was down to luck or fluke. In contrast, participants experienced increased perceptions of control over the outcome of a point during the HT condition, because they found their physical efforts, skill, and ability to have a positive impact upon the probability of a successful performance. As such, participants were afforded a greater sense of achievement, competence and, in turn, enjoyment.

The final factor that influenced participants' affective responses to the conditions was identified as: order effects. Indeed, the order that the conditions were performed appeared to impact participants' levels of enjoyment, whereby those who performed the WT condition first were considered to have enjoyed the WT condition to a greater extent, compared with those participants who had performed the HT condition first. More specifically, one participant stated that:

…say you do hardcourt tennis first and went onto the Wii you might find it a bit different…cos you have been outside already doing a real sport…you come inside and…it's not as good…

Perceived Exertion

Participants were in agreement that they expended greater energy during the HT condition compared with the WT condition. Although participants recalled investing a high amount of physical effort during the initial tennis match on the Wii, this was not maintained throughout the condition. Furthermore, the HT condition was perceived as more physically demanding because it required a range of movements from both their lower and upper body. In contrast, the WT condition was distinctly physically limiting, partly due to the multi-player format, which restricted the amount of space available that would otherwise permit attempts to resemble hardcourt tennis movements. In turn, there was an agreement among participants that if a single-player format was used whilst playing the Wii tennis game, and if they were motivated to simulate the tennis movements, then there was potential for the IVGT to be of a physical benefit. Indeed, one participant stated that:

…if you're playing it on your own, I think you can [physically benefit] because you can actually move about a bit more, and if you actually want to get into it you can, like, but with, if you've got four people then it's too packed to do it and you can't move.

Some participants also recognised a link between their enjoyment, effort and energy expenditure, whereby the more they enjoyed themselves, the more they were willing to mobilise and invest effort into their performance, which translated into higher levels of physical activity and energy expenditure. More specifically, one participant stated that: "When you're enjoying it, you use a lot more energy, you work harder and put more into it".

**Discussion**

The purpose of the present study was to compare participants' affective responses pre-, mid-, and post- their exposure to an IVGT condition (WT), and a traditional physical activity condition (HT). Whilst both conditions produced pleasant affect, the HT condition was associated with a significantly more active and valenced experience, when compared with the WT condition, at all time intervals. Such findings were further supported by the qualitative data gained from the focus group interviews, with the majority of participants communicating a better (i.e., more enjoyable) affective experience and a greater preference for the HT condition. Therefore, engaging in a game of doubles tennis on an outdoor court was conducive to a more pleasant and aroused affective state compared with a bout of WT played inside a lecture room. In contrast, Russell and Newton (2008) reported non-significant mood differences between an IVGT condition and an exercise-only condition, whilst Legrand et al., (2011) also failed to find a significant difference in valance scores between an externally imposed IVGT condition and an exercise-only condition.

In an attempt to explain why the WT condition produced less pleasant affective responses compared with the HT condition, it is useful to consider some of the participants' experiences through the application of Self-Determination Theory (Deci and Ryan, 1985). This theory proposes that in a quest for personal growth, humans actively strive to satisfy three basic psychological needs (competence, autonomy and relatedness), which are associated with the experience of pleasantly valanced affective states (Wilson and Rodgers, 2007). However, several of the qualitative themes suggest that two of these needs (autonomy and competence) were somewhat thwarted during the WT condition. Indeed, participants recalled a lack of perceived control over their Wii performance that was a consequence of the inaccuracy between their physical movements and the virtual environment, impeding upon their sense of autonomy during the task, and the extent to which they felt they were effectively interacting with their environment. In line with this contention, Boes and Krell (2010) outline the need for technological improvements to enhance the quality and intensity of the physical activity produced by IVGTs. However, the lack of control also influenced how participants attributed success (i.e., winning a point, game, set or match), whereby superior performance was more indicative of luck, as opposed to mastery. Many of the participants also agreed that the WT condition lacked competition and was not sufficiently challenging, resulting in additional decrements to perceived need satisfaction.

An additional aspect of the WT condition that potentially hindered perceptions of autonomy and competence was the multi-player format. Indeed, the multi-player format physically restricted participants in the types of movements they could execute, impeding upon their sense of choice, and their ability to demonstrate a range of tennis related skills. Furthermore, the combination of limited space with the inaccuracy of the IVGT appeared to have prevented participants from physically and mentally immersing themselves in the video game, further jeopardising the perceived effectiveness of their interaction with the virtual environment. Interestingly, some researchers advocate multi-player formats as an effective means to maintain interest and adherence to IVGT interventions that aim to promote physical activity (Foley and Maddison, 2010). Yet, without the provision of adequate space to accommodate for the increased number of bodies, multi-player formats may counteract such efforts. Indeed, Biddiss and Irwin (2010) identified space as a possible barrier to IVGT participation. However, by addressing the factors that encroached upon participants' levels of enjoyment during the WT condition, future research has

the potential to create IVGT sessions that are conducive to a more beneficial affective experience, compared with those recorded by the present study. This may, in turn, help to create a psychological climate that is more facilitative to future engagement in physical activity.

Alternatively, future researchers might wish to consider using other IVGT tasks (e.g., Wii Boxing) that may provide simpler and potentially more efficient ways of ensuring that the WT and HT conditions are closely matched in terms of both the physical and biomechanical demands afforded, and the environment in which the activities take place. Based on the previous findings of Graves et al., (2008), Wii Boxing also offers a slightly more intense level of activity compared with the other games on the Wii Sports package, making it arguably an appealing option for inclusion in future investigations. It may also be advisable for future researchers to have several check points (e.g., 5 minutes, 15 minutes, 25 minutes, 10 minutes post) for the measurement of dependent variables during and after the performance of the experimental tasks; as this may help to identify any subtle yet important differences in the affective and physiological responses of participants to the two physical activity conditions at difference time points.

However, Ekkekakis and Petruzzello (2002) also recognise that single-item measures of affect, such as the FAS, are susceptible to random measurement error that may compromise the reliability of results. Hence, it may be appropriate for future investigations to endorse multiple-item measures that are more robust; although this would compromise the ease at which affective data is collected during physical activity. In addition, a valuable endeavour for researchers and practitioners would be to combat those factors responsible for the reduced levels of arousal experienced whilst engaging in WT. With the benefit of additional qualitative information regarding the factors that influenced participants' affective responses, the decrease in arousal appears to have been connected to the repetitiveness, lack of competition and challenge, and lower levels of physical exertion experienced during the WT condition, which collectively provoked a decrease in participants' levels of arousal. Therefore, to offset the repetitiveness of IVGTs, Radon et al., (2010) suggest the inclusion of greater game diversity. Whilst in an effort to offset the associated lack of competition and challenge, Biddiss and Irwin (2010) also recommend that participants are matched according to their Wii ability, and that practitioners devise Wii tournaments. However, it should be noted that the reduced levels of arousal were not accompanied by a shift towards negatively valanced affect that is characteristic of a bored affective state. Thus, participants made a transition towards a less excitable affective state that could be described as calm and relaxed (Ekkekakis and Petruzello, 2002).

The secondary aim of the present study was to provide an indication as to the amount of energy expended during a 30-minute bout of WT and HT. The prediction equation of Keytel et al., (2005) revealed that HT resulted in significantly greater energy expenditure, compared with WT. This result was also evidenced in the qualitative findings regarding participants' greater perceived exertion during the HT condition. Such findings would also appear to compliment the general consensus within the research literature regarding the physiological health benefits of IVGTs. More specifically, the results of the present study support the contention that IVGTs are not, and should not be, a substitute for real physical activity (Graves et al., 2008). Indeed, the low levels of energy expended during the WT condition are indicative of light physical activity only and are not substantial enough to contribute to the weekly levels of physical activity recommended by the government (Graves et al., 2008; Porcari et al., 2008; Miyachi et al., 2010).

However, participants did suggest that the WT condition had the potential to be a source of substantial physical activity, but that the space limitations imposed by the multi-player format had encroached upon their ability to utilise both their lower and upper limbs. Furthermore, the lower levels of energy expended during the WT condition were also attributed by participants to

their lower levels of enjoyment, which made participants feel less obliged to invest effort trying to replicate the tennis movements. This observation further highlights the importance of the affective experience as a potential determinant of physical activity behaviour (Biddle and Mutrie, 2008).

Although the intensity of physical activity derived from IVGTs may be criticised as negligible or unsustainable (Duncan and Staples, 2010; Boes and Krell, 2010), the utility of IVGTs should not be disregarded simply because they fail to incite high intensities or long-term changes. Instead, the pleasant affective experience of such minor increases in physical activity could be harnessed as a catalyst for meaningful behaviour change (Biddle and Mutrie, 2008; Boes and Krell, 2010). Indeed, the efficacy of IVGTs within physical activity interventions may be related to their ability to provide a motivational entry point for those otherwise uninterested in the domain, which can then be developed upon with additional intervention techniques. For example, as a consequence of engaging in IVGTs that simulate sporting events, previously sedentary individuals may become more inclined to contemplate and seek out experiences of the corresponding traditional physical activity. The use of IVGTs alone has also been consistently found to increase energy expenditure over and above traditional video games that are of an inactive nature (Biddiss and Irwin, 2010; Foley and Maddison, 2010).

Whilst it has been valuable for research to examine whether IVGTs produce physical activity of a significant intensity, a possibly more fruitful avenue for future research could be to measure the extent to which IVGTs displace sedentary behaviours (Foley and Maddison, 2010). For example, with the knowledge that the participants from the present study believed that the good weather on the day of the experiment largely accounted for why they had preferred and enjoyed HT over and above WT, it is possible to speculate that if the weather conditions had been poor, many would have opted out of the HT condition. Therefore, IVGTs provide individuals with a means to counteract the tendency to revert to sedentary pursuits when the barriers to traditional forms of physical activity (i.e., poor weather) are salient (Porcari et al., 2008). Meanwhile, IVGTs may also provide sedentary populations with a steadier transition into a physically active lifestyle, which is essential for the development of long-term adherence (Biddle and Mutrie, 2008). Through the simulation of traditional physical activities, IVGTs offer inexperienced individuals the opportunity to learn the basics and familiarise themselves with the competitive rules of various exercise and sporting pursuits within the comfort of their home and at their own pace, before venturing into real-world contexts. This is somewhat consistent with the order effects theme from the focus group interviews, whereby the participants found it a more logical and enjoyable progression to begin with the IVGT condition before engaging in HT.

Whilst the results of the present study are most applicable to individuals with similar characteristics to the participants recruited, it also remains possible that individuals who are physically limited or disabled may find IVGTs even more enjoyable. Indeed, research has suggested that IVGTs can be integrated within a treatment programme as a valuable rehabilitation exercise, as a means to infuse variety (and prevent boredom), and/or to distract individual's from pain (Higgins et al., 2010; Deutsch et al., 2008). Hence, the repetition and lower intensities associated with IVGT consoles could be advantageous among specific populations. However, more research is needed to examine the affective impact of IVGTs among such populations, for which the present methodology provides a template to replicate and develop upon. In addition, future researchers will need to consider the wider social profile of such populations as well as any health inequalities that may shape access to and ownership of IVGTs and which will likely impact on physical activity participation.

Although research by Pinto and Marcus (1995), Pinto et al., (1998) and Leslie et al., (1999) suggests that the participants in the present study are likely to have been largely sedentary, future researchers should also look to measure and report participant's current levels of physical activity, as well as other potentially confounding variables (e.g., participants'

experience of HT and IVGT) across the entire sample. Such variables could also then be used as covariates in any subsequent quantitative analyses, where appropriate. The sample size used in future research might also be increased. Indeed, in order to achieve an adequate level of power (Cohen, 1992) and a medium effect size, future research using a similar experimental design to the one described herein would require approximately thirty participants (G*Power [online]).

**Conclusions**

HT performed on an outdoors court was found to result in more pleasant and activated affect, and higher levels of energy expenditure, compared with an IVGT condition in which participants played WT. Participants in the present study identified several factors that explained the affective and metabolic differences between the two conditions, including need satisfaction, the multi-player format, repetitiveness, the weather, and the order of the conditions. The qualitative data also highlighted and accounted for a decline in perceived activation that was not detected by the FAS measure. Although future IVGT-based research and interventions are still clearly needed, IVGTs may nevertheless become an effective means to displace sedentary behaviour and/or to inspire a physically active lifestyle.

**Applications**

Physical activity practitioners should not advocate the use of IVGTs as a substitute for real physical activity. Indeed, the low levels of energy expended during IVGTs are likely to be indicative of light physical activity only and will not be substantial enough to contribute to the weekly levels of physical activity recommended by the government. However, whilst the intensity of physical activity derived from IVGTs may be criticised as negligible, the utility of IVGTs should not be disregarded simply because they fail to incite high intensities. Instead, the pleasant affective experience of such minor increases in physical activity should be harnessed as a catalyst for meaningful behaviour change. Indeed, the efficacy of IVGTs within physical activity interventions may be related to their ability to provide a motivational entry point for those otherwise uninterested in the domain. The use of IVGTs alone has also been consistently found to increase energy expenditure over and above traditional video games that are of an inactive nature. IVGTs could therefore be used to provide individuals with a means to counteract the tendency to revert to sedentary pursuits when the barriers to traditional forms of physical activity are salient. In addition, IVGTs may provide sedentary populations with a steadier transition into a physically active lifestyle, which is essential for the development of long-term adherence.

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