Running Title: Single- and Dual-player exergaming in adults

Investigating the Physiological and Psychosocial Responses of Single- and Dual-Player Exergaming in Young Adults

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Abstract

Objective:

This study investigated the effect of acute exergaming on the physiological and psychosocial responses of young adults and the modulatory effect of a single- or dual-player game play situation.

Materials and Methods:

Thirty six participants (19 male; 21.7 ± 3.8 years; 23.65 ± 3.17 $kg \cdot m^{-2}$) each completed two 30-minute exergame sessions in a randomised order (single- and dual-player) whilst wearing an Actiheart® to estimate energy expenditure. Positive and negative affect, subjective vitality and indices of intrinsic motivation were assessed directly after each gaming bout.

Results:

There was no significant difference in energy expenditure or psychosocial outcomes between conditions. Although males expended more energy than females in both single- (z=-2.124, p=0.033) and dual-player situations (z=-2.679, p=0.007), females reported significantly greater vitality (z=-2.219, p=0.026) and effort/importance than males (z=-2.001, p=0.045). Conversely, males reported greater negative affect (z=-2.872, p=0.004) and pressure/tension (z=-3.295, p=0.001)). A linear mixed effects model revealed that energy expenditure during exergaming was a significant predictor of interest and enjoyment (P=0.001) and effort and importance (P=0.001). This relationship between energy expenditure and psychosocial variables was not modulated by sex or order of game play (single or dual-player first).

Conclusion:

The present results suggest that females have a more positive psychosocial response to exergaming relative to males, highlighting exergames such as Wii boxing as a potential avenue for future interventions seeking to address the low physical activity levels that characterise the young adult population.

Introduction

Regular participation in physical activity is associated with numerous physiological and psychological health benefits.[1-3] Accordingly, a physically active lifestyle is considered a choice that can profoundly and positively influence health and longevity.[4] Despite World Health Organisation guidelines that adults should engage in at least 150 minutes of moderate-to-vigorous physical activity (MVPA) throughout the week,[5] 23% of adults globally are not sufficiently active to accrue health benefits.[6]

Whilst physical activity levels appear to decline progressively with age,[7] this decline is especially pronounced in young, university-aged adults for whom physical activity is evidenced to decrease by 24% during the transition from high school to college.[8] This decrease is further compounded by an increase in sedentary behaviours;[9] in addition to time spent sitting in lectures and studying, recent studies have suggested that a significant proportion of students' time is spent playing video games.[10] Indeed, Wack and Tantleff-Dunn[10] reported that, on average, students spent 10 hours per week playing video games, with 8.5% of students spending up to 35 hours per week. Similarly, studies have shown the mean time spent playing video games to be 8.5 ± 12.2 hours per week, with 39% of students playing more than 2 hours per week.[11, 12] The popularity of game play has led to the development of games that aim to combine video game playing with physical activity in an effort to counteract the negative consequences associated with conventional, sedentary game playing without necessitating people to relinquish highly-valued behaviours.[13]

Active video games, often referred to as exergames, have been shown to significantly increase energy expenditure relative to rest or traditional sedentary video games.[14-18] However, methodological issues, including a reliance on small sample sizes, a predominant focus on children and adolescents and limited ecological validity largely constrain the interpretation of previous studies. Specifically, Miyachi et al.[15] suggested that previous studies may have underestimated the energy expenditure associated with exergames due to indirect calorimetry restricting natural play patterns.

With many contemporary video games incorporating a multi-player element, the predominant utilisation of a "single-player" mode in previous studies is unlikely to be representative of typical game play; preadolescents generally choose a multi-player dance exergame over traditional solitary physical activities,[19] with the primary reason cited for playing such games being social interaction.[20] Indeed, exergames have recently been highlighted as a mechanism to build social relationships and skills.[21] A key issue with the utilisation of single-player modes is a failure to account for the influence of competition on energy expenditure and enjoyment, which have been shown to be substantially higher when a competitive element was incorporated within video games.[22] Indeed, competition has been shown to engender greater gains when measuring performance-based outcomes, a notion supported by findings in children showing a higher energy expenditure during exergames played against a peer than against a virtual character.[23] The applicability of these findings to adults is presently unclear; Peng and Crouse[24] reported a greater energy expenditure during single-player gaming whilst Bonetti et al.[14] found no difference between single and multi-player modes. Whilst it is important to recognise that "single-player" games typically involve a virtual peer and are thus not true "single-player" modalities, these discrepancies may additionally be attributable to the utilisation of non-randomised, short duration (5 minutes or less) exergame play. Furthermore, inter-study comparisons are limited by the use of accelerometry-based assessments of exercise intensity, which are reliant on arbitrary cut-points[25] and are renowned for over- or under-estimating energy expenditure dependent on the location and activity.[26] It has been suggested that the combination of synchronised accelerometry and heart rate data demonstrate greater validity and reliability for the estimation of free-living energy expenditure.[27, 28]

A key barrier to participation in physical activity and exercise is the widespread view that exercise is not enjoyable.[29] However, it has been suggested that exergames may be perceived as being less strenuous and more enjoyable than traditional programmes, even when total energy expenditure is similar.[30] Although recent research has acknowledged the potential relationship between energy expenditure and psychosocial variables with regards to mediating the influence of an exergame-based weight loss programme,[31] further research is required to elucidate the basis for such a relationship. Indeed, the influence of acute bouts of exergaming on psychosocial responses is presently unclear and requires resolution before our understanding of long-term relationships may be advanced.

Therefore, the purpose of the present study was to investigate the effect of an aerobic-based exergame on the physiological and psychosocial responses of young adults and the modulatory effect of single- or dual-player games on these responses.

Materials and Methods

Sample Population

A total of 36 university students (19 male; 21.7 ± 3.8 years; 23.65 ± 3.17 kg·m^{-2}) were recruited and provided written informed consent to take part in this study, which was approved by the local Ethics Committee.

Experimental procedures

Stature and sitting stature to the nearest 0.1 cm (Seca Ltd. Birmingham, UK) and body mass to the nearest 0.1 kg (Seca Ltd. Birmingham, UK) were measured using standard techniques [29] and subsequently used to initialise the Actiheart to estimate energy expenditure. Body mass index was calculated (body mass (kg)/stature^2 (m^2)). Waist circumference was measured to the nearest 0.1 cm using a non-elastic anthropometric tape and measurements were taken at the narrowest point between the bottom of the ribs and the iliac crest. All measurements were undertaken by the same trained researchers with the participants barefoot and wearing minimal clothing. During this initial session, the participants were familiarised with the Wii Boxing exergame to be utilised in the study through a practice single player session; 23 participants reported previous experience of playing the specific exergame. The exergame is inherently competitive in both single and dual player modes with a possible win/lose/draw outcome in both conditions.

One week later, participants were asked to return to the laboratory in a hydrated state, having avoided caffeine and alcohol for the previous 24 hours. Participants were randomly assigned to a gaming order (single- or dual-player first), and all instructions were provided by pre-recordings to ensure consistency between participants. Each game condition was played for 30 minutes with a 12 minute rest between conditions to allow heart rate to return to baseline values. All dual-player gaming situations were performed with randomly-selected same-sex participants, which has been shown to create a non-threatening environment.[32]

Experimental Measures

During the each exergaming bout, heart rate and uni-axial accelerometery data were simultaneously recorded at a 1 minute epoch using the Actiheart® monitor (CamnTech, UK). Following skin preparation, the monitor was attached to the chest at V1 or V2 (4th intercostal) and 10 cm laterally at V4 or V5[33] using two 3M electrodes. The ActiHeart®, which was calibrated for each participant's age, body mass and stature, has been reported to provide valid and reliable measures of free-living physical activity levels.[33, 34]

Immediately after each exergaming condition, participants were asked to complete a series of questionnaires to assess the psychological responses to that exergame. Specifically, to assess subjective vitality, four items of the State Level Subjective Vitality Scale [35] were used with responses rated on a seven-point scale ranging from 1 (not at all true) to 7 (very true). The mean of the four components was taken. To assess positive and negative affect, the participants responded to nine adjectives identified by Diener and Emmons.[36] This scale consists of four positive affect adjectives (joyful, happy, pleased, enjoying/having fun) and five negative affect adjectives (depressed, worried/anxious, frustrated, angry/hostile, unhappy). Participants were requested to rate each adjective using the precursory stem, "What extent did you experience the following emotions during the experimental task?". Responses were made as to the degree that each emotion was experienced during the experiment on a 7-point scale ranging from 1 (not at all) to 7 (extremely). The mean of the components was calculated for positive and negative affect. Finally, to assess intrinsic motivation, items from the interest/enjoyment, perceived competence, effort/importance, pressure/tension and perceived choice subscales of the Intrinsic Motivation Inventory (IMI)[37] were used. Participants were requested to rate how true each statement was for them on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Data Analysis

To analyse the Actiheart recordings, a branched equation model based on accelerometry and heart rate data was utlised to estimate energy expenditure.[38] These methods have previously been reported to be valid and reliable.[27, 28] To assess the influence of order, sex and condition on energy expenditure, a mixed repeated measures ANOVA was conducted.

A total of 72 data points were available for analysis (36 participants x 2 conditions). To address the within subject correlation between repeated measures, linear mixed models were used to determine whether energy expenditure was a significant predictor of psychosocial variables. For each model, covariates sex, BMI, condition (1 vs 2 player), order (1 player first vs 2 player first) and an interaction between sex and energy expenditure, sex, order and condition and condition and order were tested. As all interactions were insignificant, they were excluded from the final models. A separate analysis was conducted to investigate the influence of order and condition on energy expenditure. To account for the multiple comparisons, a Bonferroni correction was applied to adjust confidence intervals and significance values. Effect sizes (ES) were calculated using Cohen's d formula and interpreted according to published guidelines.[39] All statistical analyses were conducted using PASW Statistics 21 (SPSS, Chicago, Il). All data are presented as means ± standard deviation. Statistical significance was set at $P \leq 0.05$.

Results

Descriptive characteristics of the study sample are reported in Table 1. There was no significant difference in age, BMI or waist circumference between those who completed single-player vs. dual-player first. Energy expenditure as a function of sex and order of play (single-player first vs. dual-player first) is presented in Figure 1. Energy expenditure did not significantly differ during single and dual player conditions (297.9 ± 132.0 vs. 292.3 ± 142.4 $J \cdot kg^{-1} \cdot min^{-1}$, respectively; $F(1,32) = 0.20$, $p = 0.71$, ES = 0.04); however, males expended more energy than females for both conditions (single-player: 363.6 ± 151.0 vs. 250.4 ± 100.6 $J \cdot kg^{-1} \cdot min^{-1}$, $F(1,32) = 7.59$, $p = 0.033$, ES = 0.88; dual-player: 332.0 ± 137.0 vs. 222.1 ± 102.9 $J \cdot kg^{-1} \cdot min^{-1}$, $F(1,32) = 8.36$, $p = 0.007$, ES = 0.92). The energy expenditure during the single-player condition was not significantly dependent on the order of play ($F(1,32) = 0.50$, $p = 0.181$, ES = 0.60). However, those who engaged in a dual-player situation first expended significantly more energy during the dual-player condition than those who participated in a single-player situation first ($F(1,32) = 8.51$, $p = 0.006$, ES = 1.11).

Females reported significantly greater vitality ($t(70) = -2.2$, $p = 0.030$) and choice than males ($t(70) = -3.1$, $p = 0.003$), whereas males reported significantly greater negative affect ($t(70) = 2.4$, $p = 0.021$) and pressure/tension ($t(70) = 3.9$, $p = 0.000$) (Table 2). There were no significant differences between sex with respect to positive affect, perceived competence, effort and importance or interest/enjoyment. Furthermore, there was no influence of condition on any of the psychosocial variables (Table 3).

The linear mixed model revealed that energy expenditure was a significant predictor of interest and enjoyment and effort and importance and that this relationship was not dependent on order, condition or sex. Specifically, as energy expenditure increased, as did interest and enjoyment ($t(65) = 2.7$, $p = 0.001$) and effort and importance ($t(65) = 3.6$, $p = 0.001$). There were no significant interactions between order, condition or sex in determining the relationship between energy expenditure and psychosocial variables.

Discussion

The purpose of this randomized, crossover design study was to compare the physiological and psychological responses of young adults during single- and dual-player exergame play. Contrary to our hypothesis, there was no significant difference in overall energy expenditure or any psychosocial variables between conditions. Nonetheless, energy expenditure was a significant predictor of participant's perceptions of effort and importance and interest and enjoyment. Interestingly, whilst males demonstrated significantly greater energy expenditure than females, irrespective of condition, no interaction was evident between sex, energy expenditure and psychosocial factors. However, females reported significantly higher vitality and perceived choice, whereas males perceived significantly greater pressure/tension and negative affect following game-play. Given these positive findings with regards to the psychosocial responses of female participants following exergaming, the present results highlight the potential utility of exergames in enhancing energy expenditure in females.

The present findings are in agreement with previous studies reporting no significant difference in energy expended between conditions.[14] However, it is pertinent to note the contradictory findings of Peng et al.[24], who reported a greater energy expenditure during single player, and Staiano et al.[23], who reported the converse. Such discrepancies could be attributed to the use of substantially shorter bout durations (5-minutes)[24], although the reliance on accelerometry to estimate energy expenditure in both of these studies limits inter-study comparisons due to the potential confounding effect of different energy expenditure prediction algorithms.[23, 40] Furthermore, the equivocal findings may be related to the games employed and, specifically, whether the single-player mode was truly single-player[40] or rather involved competing against a computer-generated opponent.[23] Indeed, with regards to the latter, it could be postulated that participants in the present study never really experienced a non-competitive gaming experience. Nonetheless, earlier work reported higher energy expenditures for children playing against peers rather than virtual characters.[23]

This study examined how different game-play modes affected not only energy expenditure but indices of intrinsic motivation. It is hypothesised that the young adults who participated in the present study may have created a different social context and indeed pressures in comparison to previously studied adolescents. This is demonstrated in the present study by the greater degree of pressure/tension and negative affect reported by the males. Players may be differentially motivated based on comparing themselves to their opponents' competence, thereby affecting their own effort and energy expenditure.[41, 42] However, it is not clear the extent to which the players were competing against or cooperating with each other, which may differentially influence energy expenditure.[43]

The linear mixed-model revealed that young adults playing an exergame alone are likely to expend more energy if they play against someone first. It is therefore possible that dual-play is more beneficial over the longer-term. Specifically, a 12-week exergaming study of children aged 9 to 12 years observed less drop-out and higher engagement among those assigned to a dual-player condition (15% attrition; 901 minutes) vs. a solitary in-home condition (64% attrition; 376 minutes).[44] However, the intensity level of play between conditions was unknown, as is the transferability of findings in children to adults.

The linear mixed-effects model revealed that effort/importance increased as energy expenditure increased. It is perhaps unsurprising that as participants' energy expenditure increased, so did their associated perceptions of effort and importance. Interestingly, energy expenditure during exergaming was not a predictor of perceived competence. Such a finding is contrary to expectation as perceived competence may indicate mastery of gaming, which would be anticipated to be associated with a greater exercise economy due to a higher proficiency and efficiency of the necessary movements and thus decreased energy expenditure. This may be attributable to the relative gaming experience of the participants, with more experienced gamers demonstrating a depressed response due to a greater state of "training" or a reduced emotional response.[45, 46] The familiarisation provided prior to the start of the present study may have negated a potential relationship between energy expenditure and perceived competence.

Interestingly, although enjoyment has been shown to be higher in dual- vs. single-player gaming,[24] there was no influence of condition on the relationship between energy expenditure and interest and enjoyment in the present study. It is interesting to note that enjoyment was highly rated in both conditions and comparable to a study in similar-aged participants.[47] Such high values contradict previous research identifying that exergames associated with greater energy expenditures are less enjoyable than more sedentary games,[17] although it is pertinent to note the potential influence of different social interaction elements across the games in this previous study which may confound the attribution of the decreased enjoyment to an increased energy expenditure *per se*. The findings in the present study infer positive health implications, especially as research has identified that university students enjoy physical activity more in a group setting rather than on their own.[48] With the frequently reported increased energy expenditure and enjoyment associated with exergaming,[29] enjoyment could be more critical for long-term adherence and sustainability rather than energy expenditure associated with acute exergaming bouts.

While some researchers suggest that exergames are perceived as more enjoyable compared to traditional aerobic exercise modalities,[29] others report decreases in positive well-being.[49] Individual factors may contribute to differential effects on energy expenditure and psychosocial variables, such as sex and game-play preference (i.e., competitive vs. solitary gaming). Specifically, energy expenditure during exergaming was dependent on sex, with males expending significantly more energy, irrespective of condition. Evidence from both biology and evolutionary psychology supports the notion of a heightened male competitive tendency.[50-52] Therefore, given that both conditions were competitive against another player (virtual or real), it seems plausible that male participants worked harder because they may be more competitive. Despite this, males reported significantly more pressure/tension and negative affect, whereas females reported greater vitality, choice and effort/importance. Nonetheless, there were no significant differences between sexes for positive affect, competence and interest/enjoyment. In a study of adolescents, boys reported enjoying dual-play in competitive contexts such as boxing, whereas girls enjoyed dual-play in co-operative contexts such as dance-based games.[53] In one study participants who self-rated as highly competitive reported higher levels of enjoyment and positive mood during a competitive gaming context, whereas participants self-rated as low in competitiveness reported higher enjoyment and motivation when placed in a non-competitive gaming context.[54] Future research should better characterize the individual factors that contribute to differential responses in energy expenditure during exergaming and how interventions can be tailored to elicit higher intensity activity.

In accord with previous research,[55, 56] and indeed UK government guidelines, the present study found that both conditions elicited an energy expenditure conducive of moderate-intensity physical activity (i.e., 3.0 to 6.0 METs; single-player: 4.3 ± 1.9 METs; dual-player: 4.2 ± 2.0 METs). Conversely, numerous studies have reported values significantly below this threshold.[57-60] It is postulated that the type, duration and context of game played, as well as further psychosocial variables underpinning game play, may explain these equivocal findings. Furthermore, in agreement with a recent meta-analysis,[40] the game utilised in the present study could incorporate whole body movements and potentially explain higher energy expenditure values. Specifically, 19.4% of participants met energy expenditure levels commensurate of vigorous-intensity physical activity (6.0 METs) and there was a wide range of METs during game play (1.3 to 9.5 METs).

The present study was associated with numerous strengths, such as the utilisation of the ActiHeart® which facilitates a more ecologically valid environment to determine energy expenditure and does not prohibit movement in the same manner as indirect calorimetry. Furthermore, the present study is the first to account for the potential influence of energy expenditure in determining the psychosocial responses associated with exergames in young adults, as well as an inclusion of a dual-player social context, strengthening external validity. The incorporation of a 30-minute gaming duration advances other studies, which have used as little as 5-minute bouts. It is unlikely that a 5-minute bout will be representative of a sustained period of exergaming. It is postulated that a 30-minute gaming period is more typical of actual gaming. Whilst the methodological design allowed additional comparisons through the randomisation of game-play order, the potential influence of the opponents' relative skill level was not controlled for, a question that may be worth addressing in future research. It is also important to note that many exergames, including the one used in the present study, involve competing against a virtual character in the single player mode. Given the evidence that suggests that humans readily anthropomorphize virtual entities[61] and that participants will treat virtual exergame players as real people (i.e., the psychological dynamics of human groups apply),[62] such modes should not be considered single-player in the true sense. Furthermore, it is important to note that the present study only considered the potential influence of competition on the relationship between energy expenditure and psychosocial variables. Future studies should seek to investigate the influence of other group dynamics on the relationship, such as social facilitation or the Kohler effect. Nevertheless, it is possible that a laboratory environment or a potential novelty effect may have artificially enhanced, or reduced, the energy expended in the current study. A further limitation worthy of consideration is the utilisation of single exergaming bouts. Whilst the sex-effect in the model accounts for the same-sex dyads, future research should seek to investigate the specific influence of sex within dual-player situations. Indeed, evidence regarding motivational gains in collective work contexts suggests that males show greater motivation when paired with a more capable female, whilst females efforts were more variable when paired with a male counterpart.[63] Although the present findings extend our knowledge surrounding the relationship between energy expenditure, psychosocial variables, sex and condition associated with exergames, caution must therefore be taken when extrapolating such findings to a more sustained game playing environment. Further research is warranted to ascertain the mediatory effect; that is, whether the game-play context per se, or indeed the specific energy expenditure during game-play, affected the psychosocial variables.

In summary, the present study showed no significant difference between the energy expended or the psychosocial experience in either a single- or dual-player condition. Energy expenditure was an important factor in effort and importance and interest and enjoyment following exergaming. Both conditions elicited energy expenditures commensurate with national physical activity recommendations. The current findings extend our understanding of the mediators of psychosocial variables, suggesting that exergames should be considered as a potential avenue for future interventions seeking to address the low physical activity levels that characterise the young adult population, especially in females given their more positive psychosocial response to exergaming.

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Table 1. Participant descriptive characteristics

	Total	Males	Females
N	36	19	17
Age (years)	22.0 ± 4.2	22.5 ± 5.5	21.5 ± 2.3
Stature (m)	1.7 ± 0.1	1.8 ± 0.1	1.7 ± 0.1*
Body mass (kg)	69.3 ± 13.5	77.4 ± 12.0	60.4 ± 8.6*
BMI (kg·m^{-2})	23.3 ± 3.5	24.5 ± 4.0	21.8 ± 2.4*
Waist circumference (m)	0.8 ± 0.1	0.8 ± 0.1	0.7 ± 0.1*

Note. Mean ± SD. *P < 0.05

Table 2. Descriptive characteristics of psychosocial variables determined immediately following each exergame by sex.

	Male (***n*** **= 38)**	**Female** (***n*** **= 34)**	**Effect size** **(*Cohens d*)**
Vitality	5.1 ± 1.1	5.7 ± 1.0*	0.52
Positive affect	5.7 ± 0.7	5.9 ± 0.9	0.32
Negative affect	2.3 ± 0.8	1.8 ± 1.0**	0.54
Pressure or tension	2.5 ± 1.1	1.7 ± 0.7**	0.87
Competence	5.3 ± 0.9	4.8 ± 1.2	0.47
Choice	5.7 ± 1.0	6.3 ± 0.6**	0.73
Effort and importance	5.0 ± 1.1	5.5 ± 1.1*	0.45
Interest and enjoyment	5.4 ± 1.1	5.5 ± 1.2	0.09

Note. Means ± SD. All parameters determined from a 7-point scale. *n* = number of participants * 2 conditions. Significant influence of sex: *p<0.05, **p<0.001

Table 3. Descriptive characteristics of psychosocial variables by condition.

	Single-Player (n = 36)	**Dual-Player (n = 36)**	**Total (n = 72)**	**Effect size (Cohens's d)**
Vitality	21.4 ± 4.2	21.5 ± 4.5	21.5 ± 4.3	0.02
Positive affect	23.1 ± 3.0	23.1 ± 3.8	23.1 ± 3.4	0.00
Negative affect	10.2 ± 4.2	10.2 ± 5.0	10.2 ± 4.6	0.00
Pressure or tension	2.2 ± 1.0	2.1 ± 1.0	2.1 ± 1.0	0.10
Competence	4.9 ± 1.1	5.2 ± 1.1	5.1 ± 1.1	0.29
Choice	6.0 ± 0.9	6.1 ± 0.9	6.0 ± 0.9	0.11
Effort and importance	5.2 ± 1.2	5.3 ± 1.1	5.2 ± 1.1	0.09
Interest and enjoyment	5.4 ± 1.0	5.5 ± 1.2	5.5 ± 1.1	0.09

Note. Means ± SD. All parameters determined from a 7-point scale. n = 36 participants * 2 conditions.

Table 4. Linear mixed model of psychosocial predictors of exercise intensity.

	β	95% LCI	95% UCI	p value
Condition – first game-play session	0.06	-0.02	0.14	0.136
Order – single-player first	-0.30	-0.53	-0.06	0.016*
Vitality	-0.01	-0.03	0.01	0.446
Positive Affect	0.02	-0.02	0.05	0.334
Negative Affect	0.00	-0.01	0.02	0.807
Pressure or Tension	-0.07	-0.16	0.01	0.082
Perceived Competence	-0.07	-0.14	0.00	0.042*
Perceived Choice	0.01	-0.08	0.10	0.826
Effort and Importance	0.11	0.03	0.19	0.007**
Interest and Enjoyment	0.04	-0.06	0.15	0.382
Male x Single-Player	0.74	0.40	1.09	<0.001**
Male x Dual-Player	0.70	0.36	1.05	<0.001**
Female x Single-Player	0.16	0.05	0.26	0.006**

Note. *p<0.05, **p<0.001. Dependent variable – log of energy expenditure. Reference category: Condition – second game-play; Order – dual-player first; Sex x Condition – female, dual-player. LCI = Lower confidence interval. UCI=Upper confidence interval.