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Research article

The Contribution of Gaelic Football Participation to Youth Physical Activity Levels

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Abstract

The primary aim of this study was to describe the contribution of Gaelic football participation to youth physical activity (PA) levels. Secondary aims were to objectively quantify the overall daily PA levels of participants across sex and age, to determine the PA levels achieved during Gaelic football practice sessions and games, and to compare PA levels on days with organized sporting activity (sports days) and days without organized sporting activity (non-sports days). One hundred and sixty adolescents (87 male, 73 female; mean age 14.5 ± 1.8 yrs.) wore an activPAL accelerometer to determine total sitting/lying time, standing time, light intensity physical activity (LIPA), moderate physical activity (MPA), vigorous physical activity (VPA) and moderate-to-vigorous physical activity (MVPA) during a seven day measurement period, including during Gaelic football participation. Participants achieved an average of 58.5 ± 23.6 minutes of MVPA daily. Males accumulated significantly more MVPA daily than females (Males=70.8±22.1 min; Females = 45.5 ± 16.5 min; $p < 0.001$; $\eta_p^2 = 0.401$) and time spent in MVPA daily significantly decreased with age ($p < 0.001$; $\eta_p^2 = 0.299$). Participants accumulated significantly more MVPA during games (36.0 ± 9.2 min/hr (60%)) than practice sessions (29.0 ± 8.3 min/hr (48%); $p < 0.001$; $d = 0.80$). On sports days, participants accumulated significantly more time in MVPA (Sports Days = 70.1 ± 36.0 min; Non-Sports Days = 54.2 ± 34.0; $p < 0.001$; $d = 0.45$) and were 2.16 times more likely to achieve 60 minutes of MVPA (OR = 2.16; 95% CI = 1.60–2.92) than on non-sports days. The results reveal that Gaelic football provides an opportunity for adolescents to accumulate PA, however, participants currently spent more than 50% of their practice time inactive or in low intensity activities. An opportunity remains to enhance the contribution of Gaelic football to overall daily PA levels, by replacing time spent inactive with time in MVPA.

Key words: Adolescent, MVPA, youth sports, accelerometer, guidelines.

Introduction

Regular participation in physical activity (PA) during childhood and adolescence has a positive impact on a range of health markers, including adiposity, blood lipid profiles, bone health and mental health (Poitras et al., 2016). PA in adolescence indirectly affects adult health status by increasing the probability of becoming more active in adulthood, which in turn is linked to more favourable health outcomes (Hallal et al., 2006). Recently, the World Health Organization (WHO) have published a new draft of PA guidelines, which recommend youth achieve at least an average of 60 minutes per day of moderate-to-vigorous physical activity (MVPA) across the week (World Health Organization, 2020). In contrast, the current Irish PA guidelines recommend youth should achieve a minimum of 60 minutes of MVPA every day (Department of Health and Children and The Health Service Executive, 2009). International research indicates that approximately 78% of males and 84% of females fail to attain this guideline of 60 minutes of MVPA daily (Sallis et al., 2016). Furthermore, the prevalence of achieving PA guidelines significantly decreases throughout adolescence, with the greatest decline observed in females (Corder et al., 2015; Harding et al., 2015). Such high levels of physical inactivity are a public health concern, given the important role PA plays in the prevention of overweight and obesity during childhood and adolescence (Hills et al., 2011). This is particularly relevant considering that the number of adolescents classified as obese globally has increased substantially from 11 million in 1975, to 125 million in 2016 (Abarca-Gómez et al., 2017).

Organized sports (OS) participation has been identified as a key tool for the provision of MVPA in youth (Ridley et al., 2018; Trost et al., 2014). Participation in OS is particularly popular among youth, with 40-59% of children and adolescents across Europe participating regularly (Tremblay et al., 2016). However, evidence is conflicting on the potential of OS participation to enhance the attainment of PA guidelines in youth. Research has demonstrated that adolescents who participate in OS are significantly more physically active (Hebert et al., 2015; Kokko et al., 2018; Marques et al., 2016), and more likely to meet the PA guidelines than their non-participating peers (Sprengeler et al., 2019). Additionally, OS participants accumulate more MVPA on sports days than on non-sports days (Mooses and Kull, 2019). However, evidence does suggest that OS makes a relatively small contribution to the daily PA levels of adolescents (Koorts et al., 2019), with 72-80% of OS participating youth failing to achieve the recommended amount of PA daily (Telford et al., 2016; Vella et al., 2016). Significant sex differences are also apparent among OS participating youth, with females consistently accumulating less time in MVPA daily and are less likely to meet the MVPA guidelines than their male counterparts (Marques et al., 2016; Telford et al., 2016). In addition, females are less likely to participate in OS and display greater dropout rates from OS than males (Howie et al., 2016).

Research investigating the PA contribution of OS in youth using device-based monitors is limited to a small range of sports, including soccer (Cohen et al., 2014a; Sacheck et al., 2011), netball (Guagliano et al., 2013), basketball (Wickel and Eisenmann, 2007), flag football

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(Schlechter et al., 2017), ice hockey (Kanters et al., 2015), baseball/softball (Leek et al., 2011) and Australian Rules football (Ridley et al., 2018). The majority of these studies determined the PA contribution of practice sessions, with participants spending between 30-55% of practice time in MVPA (Cohen et al., 2014a; Kanters et al., 2015; Leek et al., 2011; Ridley et al., 2018; Schlechter et al., 2017; Wickel and Eisenmann, 2007). In a further analysis of the PA contribution of youth OS in practice and games, it was highlighted that participants spend between 3-14% (2-8 minutes) more time in MVPA during a practice session than during a game (Guagliano et al., 2013; Tomlin et al., 2015; van den Berg and Kolen, 2015). These findings suggest that the level of MVPA accumulated during youth OS varies greatly depending on the sport type and context (practice or game).

Gaelic football is the most popular team-based sport in Ireland, with 10.4% of the population holding membership in one of 2,600 registered clubs (Sport Ireland, 2017), with 32% of Irish youth aged 12-18 years participating regularly in the sport (Woods et al., 2018). Gaelic football is a field-based invasive team sport, played between two teams of 15 active players on a rectangular grass surface (Cullen et al., 2017). Similar to Australian Rules football and soccer, Gaelic football is a multidirectional sport, characterized by unpredictable bursts of high intensity anaerobic activity, interspersed with sustained light to moderate aerobic activity (Cullen et al., 2013; Malone et al., 2017). During these periods of high intensity activity, players must utilize both upper and lower limb manipulation of the ball to perform several skills, such as hand passing, kick passing, shooting, blocking and tackling (Shovlin et al., 2018). This suggests that high levels of MVPA may be accumulated during Gaelic football practice and game settings.

Given the variation and limitations of the current literature, a more comprehensive examination of the overall daily PA levels of OS participating youth and the PA levels attained during OS is timely. Also, no research to date has examined the contribution of Gaelic football participation to overall PA levels in youth. Therefore, the primary aim of this study was to describe the contribution of Gaelic football participation to youth PA levels. Secondary aims of this study were to objectively quantify the overall daily PA levels of participants across sex and age, to determine the PA levels achieved during Gaelic football practice sessions and games, and to compare PA levels achieved on sports days and non-sports days.

Methods

Participants

Gaelic football was the OS selected for this study, as it has the highest participation rates among Irish youth (Woods et al., 2018). A total of 165 adolescents (90 male, 75 female) aged 12-18 years (mean age = 14.3 ± 1.6 years) participated in this study. A convenience sample of five clubs in the midlands and western regions of Ireland were approached to take part in the study. A total of three clubs agreed to participate. Thirty male and female participants were recruited from these clubs across three age groups (12-13 (Under 14), 14-15 (Under 16), and 16-17 years (Under 18)) in accordance with the structure of competitions for this sport. Only fifteen participants were recruited from the under 18 female group due to the low numbers of available active players. Written informed consent was first obtained from club executive committees. Detailed information sheets were provided to all coaches, parents, and club players. Written informed parental consent and participant assent was obtained prior to the commencement of the study. Ethical approval was granted from the Athlone Institute of Technology Research Ethics Committee and this study was carried out in accordance with the Declaration of Helsinki.

Study protocol

Data collection took place over a one-week period, which was scheduled to include a minimum of one practice session and one game. Data was collected at the Gaelic football clubs just prior to an organized practice session. Participant's height and weight were first recorded. The activPAL3 micro (activPAL^{3M}; PAL Technologies Ltd., Glasgow, UK) activity monitors were distributed. A clear demonstration of how the device was to be attached, when the device was to be worn and what to do if the device was misplaced was provided. The coaches were provided with a diary to record the start and finish time of each practice session and game, and to record each participant's attendance and involvement during the practice sessions and games. After seven days, the primary investigator returned to collect the activity monitors.

Anthropometry

Height and weight were measured following standard procedures. Participants were instructed to remove their shoes, socks, and any heavy clothing prior to measurement. Height was measured to the nearest 0.1cm using a portable stadiometer (Marsden model HM-250P, Marsden weighing machine group, UK). Weight was measured to the nearest 0.1kg using a portable electronic scale (Seca model 813, Seca Corporation, Hanover MD). All anthropometric measures were used for descriptive purposes.

Physical activity assessment

The activPAL^{3M} activity monitor, measuring 24x45x5mm and weighting 9g, was the objective measurement tool used to assess free-living PA levels in this study. The activPAL^{3M} is a triaxial accelerometer that has been established as a valid measure of body posture (i.e. sitting/lying versus standing) and for quantifying sedentary time and PA in youth (Dowd et al., 2012b; Ridgers et al., 2012). The activPAL^{3M} recorded information in 15s epochs, which aids in the effective capture of the intermittent patterns of children and adolescents PA behavior (Trost et al., 2005).

The activPAL^{3M} device was first waterproofed by placing it into a small flexible nitrile sleeve. Under the supervision of the primary investigator, the participants attached the activPAL^{3M} directly to the skin on the midline of the anterior aspect of the right thigh using a transparent dressing (10x10cm of hypoallergenic Tegaderm™ Foam Adhesive Dressing). Participants were instructed to wear

the activPAL^{3M} 24 hours per day (except while swimming or bathing) for a total of seven consecutive days, while maintaining their normal daily routines. The participants were provided with additional adhesive dressings, instructions detailing how to change the dressings and an activity log to record any time the accelerometer was removed and reapplied over the 7-day period. A 24-hour period was defined from 5 am to 5 am the following day.

The activPAL Professional Software™ (version 7.2.32) was used to access the recorded epoch data for the 7-day period and the data files were exported to a Microsoft Excel 2010 (Redmond, WA, USA) file format to be processed. The protocol used for data collection and reduction is described in detail elsewhere (Dowd et al., 2012a). Briefly, participant data was determined acceptable for analysis if there was one practice session and one game recorded, and a minimum of four valid days of activity (including one weekend day). A valid day was determined as a measured day with ≤4 hour's non-wear time during waking hours. Non-wear time was defined as a period with ≥60 minutes of consecutive zero activity counts. The amount of waking time was calculated by subtracting bedtime from rise time. To estimate bed hours, the first registered non-sedentary epoch each day was identified as the rise time while the last registered non-sedentary epoch followed by an uninterrupted sedentary period (>2h) was identified as the time participants went to bed (Dowd et al., 2012a). Breaks in bed hours (i.e. small breaks between bedtime and rise time for visits to the bathroom etc.) were identified by manual assessment of the data.

The output files were examined to produce daily PA variables, which include sitting/lying time, standing time, light intensity physical activity (LIPA), moderate intensity physical activity (MPA), vigorous physical activity (VPA) and MVPA. Total sitting/lying time and standing time was calculated by summing the total number of seconds spent in sitting/lying and standing postures over the 24-hour measurement period, as determined by the activPAL^{3M} algorithms. LIPA was categorized as all time spent in a stepping behavior at an intensity of less than 3 metabolic equivalents (METS). Previously developed and validated thresholds for the determination of MPA (9282 counts per 15 second epoch) and VPA (16100 counts per 15 second epoch) were utilized (Hayes et al., article in preparation). MVPA was calculated by summing the time spent in MPA and VPA.

In previous research, compliance with PA guidelines has been evaluated using different methods (Mooses and Kull, 2019), with some studies assessing compliance using the guideline of 60 minutes of MVPA per measured day (Days Method) (Koorts et al., 2019; Marques et al., 2016), while other studies assessed compliance using the guideline of an average of 60 minutes of MVPA across the measured days (Average Method) (Silva and Santos, 2017; Sprengeler et al., 2019). In this analysis both methods were utilized to determine compliance with the PA guidelines.

A sports day was defined as any day that the participants took part in an organized Gaelic football practice session or game, as recorded in the coach's diary. In addition, the start and finish times of each practice session and game were identified within the output files and the PA variables during these periods were also quantified. To control for the variation in duration time between practice sessions and games, the PA variables during these Gaelic football sessions were defined as minutes per hour (min/hr). This was achieved by dividing the amount of time spent in each PA variable by the duration of each practice session or game and then multiplying by 60.

Statistical analysis

Descriptive statistics for the study sample are presented as means and standard deviations (SD). Variables were tested for the assumption of normality using the Shapiro-Wilk's test and homogeneity of variance of data was investigated using the Levene's test. A two-way analysis of variance (ANOVA) was conducted to examine the interaction and main effects of sex and age on the number of activPAL^{3M} wear days (4 days, 5 days, 6 days and 7 days). A one-way ANOVA was conducted to examine the effect of activPAL^{3M} wear days on each PA intensity (sitting/lying, standing, LIPA, MPA, VPA and MVPA). A two-way ANOVA was conducted to examine the interaction and main effects of sex (male and female) and age (Under 14, Under 16 and Under 18) on each PA intensity. Where a main effect was observed, Tukey post-hoc and pairwise comparisons were completed as follow-up analyses. Partial eta squared values (η_p^2) of 0.01, 0.06 or 0.14, represented small, medium and large effect sizes respectively (Cohen, 1988). Differences in means of each PA intensity between OS practice sessions and games, and between sports days and non-sports days were detected using independent samples t-tests. Effect sizes were calculated using Cohen's d, where d = 0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen, 1988).

A logistic regression was performed to determine the effect of sports days and non-sports days on the likelihood that participants would achieve 60 minutes of MVPA. Data was presented as adjusted odds ratios for age and sex and 95% confidence intervals. Statistical analyses were performed using IBM SPSS 26.0 (SPSS, Inc; Chicago, IL) and the level of statistical significance was set at $p < 0.05$.

Results

Participant characteristics

Descriptive characteristics of the participants are displayed in Table 1. A total of 32 participants provided four valid days of accelerometer data (20%), with 82 participants providing five valid days (51%), 35 participants providing six valid days (22%) and 11 participants providing seven valid days (7%). Five participants were excluded from the analysis due to failure to achieve the minimum number of valid days or lost accelerometer devices. The final sample included 160 participants (87 male, 73 female; mean age 14.5 ± 1.8 yrs). There was no statistically significant interaction effect between sex and age on the number of activPAL^{3M} wear days ($F_{2,154} = 1.746$; $p = 0.178$; $\eta p^2 = 0.022$), and no statistically significant main effect of sex ($F_{1,154} = 0.385$; $p = 0.536$; $\eta p^2 = 0.002$) or age ($F_{2,154} = 0.237$; $p = 0.789$; $\eta p^2 = 0.003$) on the number of activPAL^{3M} wear days. The number of wear days did not have a statistically significant effect on each PA intensity (Sitting/lying: $F_{3,156}$

= 0.444; p = 0.722; Standing: $F_{3,156}$ = 0.392; p = 0.759; LIPA: $F_{3,156}$ = 0.774; p = 0.510; MPA: $F_{3,156}$ = 0.631; p = 0.596; VPA: $F_{3,156}$ = 0.728; p = 0.537; MVPA: $F_{3,156}$ = 0.795; p = 0.498).

Table 1. Descriptive characteristics of the total population and each participant group. Values are presented as mean (±SD).

	Age (yrs)	Height (m)	Weight (kg)
U14 Males (n = 29)	12.4 (0.5)	1.57 (.05)	48.5 (3.1)
U14 Females (n = 29)	12.6 (0.4)	1.56 (.04)	46.6 (3.9)
U16 Males (n = 29)	14.6 (0.4)	1.68 (.03)	62.5 (3.1)
U16 Females (n = 30)	14.4 (0.5)	1.62 (.03)	59.6 (4.7)
U18 Males (n = 28)	16.7 (0.4)	1.79 (.03)	68.1 (2.7)
U18 Females (n = 15)	16.2 (0.5)	1.66 (.02)	60.5 (4.3)
Overall (n = 160)	14.5 (1.8)	1.64 (.08)	57.6 (8.3)

Overall daily physical activity levels

The distribution of waking time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA across sex and age are displayed in Figure 1. The average daily minutes (proportion of day) spent sitting/lying was 558.7±79.3 min (64%), spent standing was 178.6 ± 52.3 (21%), spent in LIPA was 70.2 ± 18.2 min (8%), spent in MPA was 36.6 ± 13.2 min (4%), spent in VPA was 21.9 ± 13.1 min (3%), and spent in MVPA was 58.5 ± 23.6 min (7%). There was a statistically significant interaction effect between sex and age on sitting/lying ($F_{2,154}$ = 3.339; p = 0.38; η_p^2 = 0.042), standing ($F_{2,154}$ = 3.583; p = 0.30; η_p^2 = 0.044), LIPA ($F_{2,154}$ = 5.540; p = 0.005; η_p^2 = 0.067), and VPA ($F_{2,154}$ = 5.301; p = 0.006; η_p^2 = 0.064). No statistically significant interaction effect was found between sex and age on MPA ($F_{2,154}$ = 1.348; p = 0.263; η_p^2 = 0.017) and MVPA ($F_{2,154}$ = 2.075; p = 0.129; η_p^2 = 0.026).

A statistically significant main effect of sex was observed, with males spending significantly more time than their female counterparts in sitting/lying ($F_{1,154}$ = 9.910; p = 0.002; η_p^2 = 0.060), MPA ($F_{1,154}$ = 55.494; p < 0.001; η_p^2 = 0.265), VPA ($F_{1,154}$ = 84.791; p < 0.001; η_p^2 = 0.355) and MVPA ($F_{1,15\ 4}$ = 103.014; p < 0.001; η_p^2 = 0.401). Statistically significant main effects of age were also observed, with time spent sitting/lying significantly increasing with age ($F_{2,154}$ = 7.409; p = 0.001; η_p^2 = 0.088), while time spent in MPA ($F_{2,154}$ = 18.133; p < 0.001; η_p^2 = 0.191), VPA ($F_{2,154}$ = 25.925; p < 0.001; η_p^2 = 0.252) and MVPA ($F_{2,154}$ = 32.873; p < 0.001; η_p^2 = 0.299) significantly decreased with age.

Depending on the method used, the overall compliance with the PA guidelines ranged from 6% (Days Method) to 31% (Average Method). Irrespective of the method used, differences in compliance with the guidelines were apparent across sex and age. Using the average method, 57% of males and 21% of females attained the guidelines, while 53% of the U14 age group, 26% of the U16 age group and 21% of the U18 age group successfully met the guidelines. Using the days method, 10% of males and 1% of females attained the guidelines, while 14% of the U14 age group, 2% of the U16 age group and 2% of the U18 age group successfully met the guidelines.

Physical activity levels during Gaelic football

The distribution of time spent in sitting/lying, standing, in LIPA, MPA, VPA and MVPA during practice sessions and games are described in Table 2. A total of 196 practice sessions and 171 games were measured, equating to an average of 1.2 practice sessions and 1.1 games for each participant. The average duration for practice sessions was 63.1 ±4 .0 min and 73.8 ± 6.1 min for games for the entire sample. Overall, significantly more time was spent in MPA

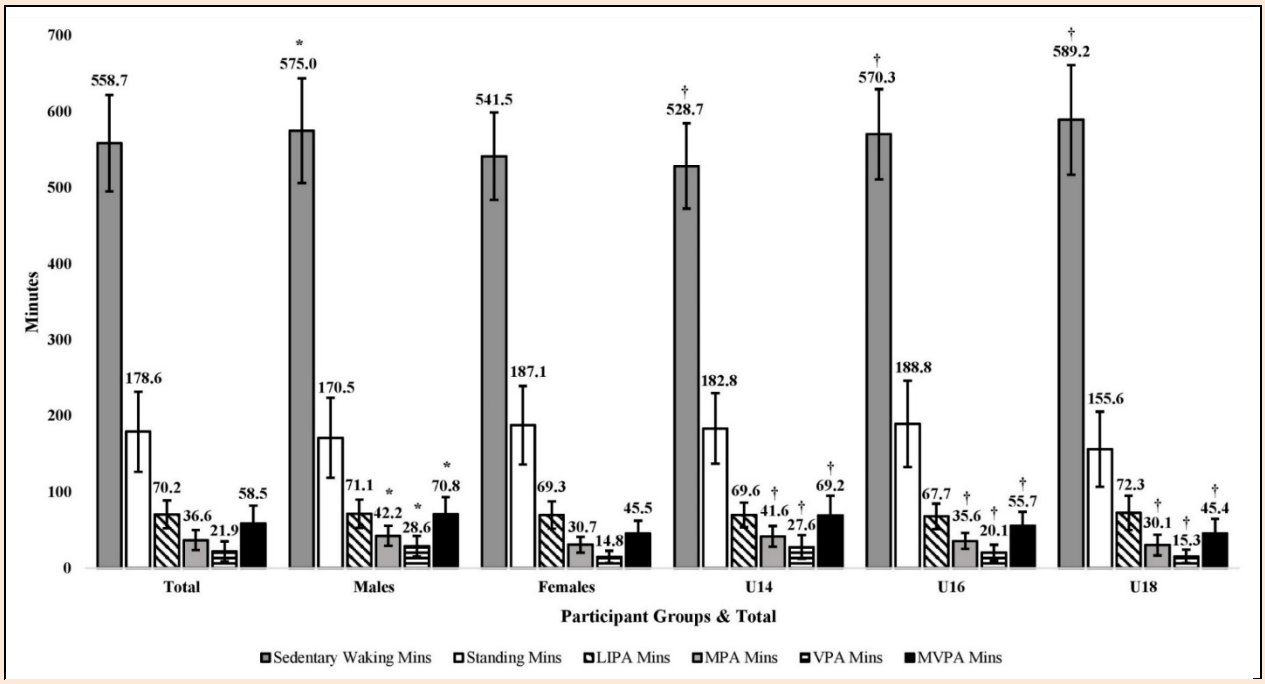

Figure 1. Mean daily physical activity intensity (minutes) across all participant groups. * Significant difference between male and female participants (p < 0.05); † Significant difference between age groups (p < 0.05).

Table 2. Physical activity intensity (minutes per hour) during practice sessions and games for the total population and each participant group. Values are presented as mean (± SD).

	Overall (n=160)			U14 Males (n=29)			U14 Females (n=29)			U16 Males (n=29)			U16 Females (n=30)			U18 Males (n=28)			U18 Females (n=15)		
	Practice	Game	d	Practice	Game	d	Practice	Game	d	Practice	Game	d	Practice	Game	d	Practice	Game	d	Practice	Game	d
Sitting/ lying	3.5 (4.9)	3.8 (4.8)	.06	2.3 (1.0)	3.1 (4.2)	.26	6.2 (6.7)	5.5 (7.8)	.09	2.8 (4.7)	4.2 (4.5)	.30	3.0 (3.1)	2.9 (6.1)	.02	6.1 (5.0)	3.7 (1.0)	.67	2.8 (1.5)	4.8 (3.6)	0.73
Standing	16.7 (5.5)	11.5 (5.9)*	**.91**	15.3 (3.8)	12.6 (4.3)	.67	18.8 (5.1)	13.6 (3.8)#	**1.16**	13.7 (5.7)	8.1 (5.3)#	**1.02**	19.8 (4.6)	15.2 (4.1)#	**1.05**	11.7 (4.3)	9.4 (4.0)	.55	17.5 (3.3)	13.8 (3.5)#	**1.09**
LIPA	10.7 (3.5)	8.7 (4.0)*	**.53**	12.0 (2.7)	8.4 (3.7)#	**1.11**	9.9 (2.8)	10.3 (4.5)	.11	10.2 (3.5)	7.7 (2.9)†	**.78**	11.9 (4.9)	10.0 (4.2)	.42	9.8 (2.0)	9.0 (3.6)	.27	12.8 (2.5)	9.3 (4.2)†	**1.01**
MPA	12.5 (3.7)	13.9 (3.6)*	**.38**	14.0 (1.6)	14.4 (2.9)	.17	14.0 (4.0)	12.0 (5.1)	.44	14.5 (3.4)	13.8 (4.0)	.19	10.2 (3.0)	12.3 (3.4)	.65	11.9 (2.2)	14.9 (4.8)	.80	9.6 (2.1)	12.2 (3.4)†	**0.92**
VPA	16.6 (7.5)	22.1 (9.4)*	**.64**	16.4 (4.5)	21.5 (9.2)†	**.70**	11.1 (6.2)	18.6 (4.5)*	1.38	18.8 (8.0)	26.2 (9.6)†	**.84**	15.1 (6.1)	19.6 (7.0)	.68	20.5 (5.9)	23.0 (7.1)	.38	17.3 (3.6)	19.9 (6.6)	0.49
MVPA	29.1 (8.3)	36.0 (9.2)*	**.80**	30.4 (4.6)	35.9 (8.4)†	**.80**	25.1 (8.6)	30.6 (6.4)†	**.73**	33.3 (8.5)	40.0 (7.9)†	**.82**	25.3 (8.1)	31.9 (7.5)†	**.85**	32.4 (5.3)	37.9 (4.6)†	**1.11**	26.9 (4.7)	32.1 (7.2)†	**0.85**

d = Cohen's . * p ≤ 0.001, # p < 0.01 , † p < 0.05 between practice and game.

Table 3. Physical activity intensity (minutes) during sports day and non-sports day for the total population and each participant group. Values are presented as mean (± SD).

	Overall (n=160)			U14 Males (n=29)			U14 Females (n=29)			U16 Males (n=29)			U16 Females (n=30)			U18 Males (n=28)			U18 Females (n=15)		
	S Day	Non-S Day	d	S Day	Non-S Day	d	S Day	Non-S Day	d	S Day	Non-S Day	d	S Day	Non-S Day	d	S Day	Non-S Day	d	S Day	Non-S Day	d
Sitting/ lying	549.1 (134.4)	551.3 (144.2)	.01	528.8 (141.7)	523.4 (151.1)	.03	487.9 (121.3)	513.1 (145.3)	.19	568.6 (74.4)	582.7 (103.4)	.16	543.0 (99.2)	548.2 (165.0)	.04	676.3 (118.7)	610.7 (117.4)	0.56	529.2 (105.4)	594.5 (141.5)*	**0.52**
Standing	183.0 (92.0)	177.8 (84.3)	.05	193.4 (134.3)	172.6 (95.2)	.18	197.1 (46.6)	187.3 (55.9)	.19	174.4 (55.7)	171.0 (83.6)	.05	216.3 (92.2)	202.4 (102.9)	.14	105.3 (69.3)	171.2 (88.5)*	**0.83**	149.2 (80.6)	145.5 (57.2)	0.05
LIPA	70.1 (26.1)	69.9 (31.1)	.007	68.7 (24.5)	72.3 (30.4)	.13	75.5 (20.7)	67.7 (20.3)†	**.38**	75.8 (22.7)	72.3 (35.7)	**0.12**	67.5 (22.9)	59.5 (28.7)	.31	55.6 (36.0)	71.1 (33.0) †	**0.45**	74.8 (37.8)	63.7 (38.8)	0.29
MPA	40.9 (21.2)	34.9 (19.9)*	**.29**	47.1 (19.6)	47.6 (24.2)	.02	45.7 (23.4)	33.7 (14.3)*	**.62**	47.0 (16.3)	38.1 (16.9)*	**0.54**	32.8 (15.2)	28.4 (17.3)	.27	39.1 (31.3)	35.0 (22.9)	0.15	30.1 (9.5)	26.3 (8.5)	0.42
VPA	29.2 (22.2)	19.3 (18.2)*	**.48**	47.9 (28.2)	35.0 (22.0)#	**.51**	25.1 (16.4)	15.2 (12.1)*	**.69**	33.0 (20.6)	21.3 (19.4)*	**0.58**	20.2 (14.8)	12.3 (13.4)*	**.56**	23.5 (13.7)	19.6 (16.7)	0.25	19.4 (11.2)	11.9 (8.0)*	**0.77**
MVPA	70.1 (36.0)	54.2 (34.0)*	**.45**	94.9 (38.2)	78.4 (40.4)†	**.42**	70.8 (33.6)	48.9 (24.0)*	**.75**	80.0 (31.9)	59.4 (32.4)*	**0.64**	53.0 (22.5)	40.7 (26.8)#	**.50**	62.7 (36.3)	54.6 (32.9)	0.23	49.5 (26.9)	38.2 (17.2) †	**0.50**

S Day = sports day, Non-S Day = non-sports day, d = Cohen's . * p ≤ 0.001, # p < 0.01 , † p < 0.05 between sports day and non-sports day.

(Practice = 21%; Games = 23%; p = 0.011; d = 0.38), VPA (Practice = 28%; Games = 37%; p < 0.001; d = 0.64) and MVPA (Practice = 48%; Games = 60%; p < 0.001; d = 0.80) during games than during practice sessions. Conversely, during practice sessions, participants spent significantly more time in standing (Practice = 28%; Games=19%; p < 0.001, d = 0.91) and LIPA (Practice = 18%; Games = 15%; p = 0.001, d = 0.53) than during games. Significant differences for time spent in each PA intensity between practice sessions and games were observed for each individual participant group. The mean amount of time spent in MVPA during games was significantly greater than during practice sessions across all participant groups (U14 Males: p = 0.020, d = 0.80; U14 Females: p = 0.036, d = 0.73; U16 Males: p = 0.019, d = 0.82; U16 Females: p = 0.030, d = 0.85; U18 Males: p = 0.031, d = 1.11; U18 Females: p = 0.044, d = 0.085).

Sport and physical activity

A description of waking time spent sitting/lying, standing, in LIPA, MPA, VPA and MVPA during sports days and non-sports days are presented in Table 3. Overall, on sports days participants accumulated significantly more time in MPA (p < 0.001; d = 0.29), VPA

($p < 0.001$; $d = 0.48$) and MVPA ($p < 0.001$; $d = 0.45$) than on non-sports days. Significantly more time was spent in MVPA during sports days than non-sports days for all participant groups (U14 Males: $p = 0.046$, $d = 0.42$; U14 Females: $p < 0.001$, $d = 0.75$; U16 Males: $p < 0.001$, $d = 0.64$; U16 Females: $p = 0.003$, $d = 0.50$; U18 Females: $p = 0.025$, $d = 0.050$) with the exception of the U18 Male group ($p = 0.284$; $d = 0.23$).

After adjustment for age and sex, logistic regression identified that participants were 2.16 times more likely to achieve the 60 minutes of MVPA on sports days than on non-sports days (OR = 2.16; 95% CI = 1.60–2.92; Table 4).

Table 4. Odds ratios for sports participation as a predictor of meeting physical activity guidelines.

	Non-Sports Day	Sports Day
Meeting PA Guidelines % (number of days)	36.2% (230)	55.1% (134)
Not Meeting PA Guidelines % (number of days)	63.8% (405)	44.9% (109)
OR (95% CI)	1.00	Adjusted 2.16 (1.60 – 2.92) *

Odds ratios adjusted for age and sex; * Odds ratio is significant ($p < 0.05$); PA = physical activity, OR = odds ratio.

Discussion

To the author's knowledge, this is the first study to quantify the contribution of Gaelic football participation to the overall daily PA levels in youth using device-based measures. These findings highlight that participants achieved an average of 58 minutes of MVPA daily. Males were shown to accumulate significantly more MVPA than their female counterparts, while the amount of MVPA significantly decreased as age increased. Depending on which approach was used to determine compliance, a total of 6-31% of participants achieved the PA guidelines. Participants were significantly more physically active on sports days compared to non-sports days. Overall, while participation in Gaelic football provided an opportunity to accumulate PA, it was not sufficient to support all participants to meet the PA guidelines.

It has been stated that OS have multifaceted outcome goals and PA attainment is not the sole objective, thus making it unrealistic to expect participants to achieve the PA guidelines in one session (Ridley et al., 2018). However, there remains potential to improve the contribution of youth Gaelic football participation to overall daily MVPA. A limited number of studies have investigated the levels of PA attained during youth sport, reporting considerable variation in MVPA based on sport type, context (practice or game) and age (Schlechter et al., 2017). Previous studies of similar invasion field-based sports to Gaelic football, such as Australian rules football (Ridley et al., 2018) and soccer (Cohen et al., 2014a; Leek et al., 2011; Wickel and Eisenmann, 2007) have highlighted that 30-55% of practice time was spent in MVPA. The findings in this study are comparable to these earlier studies, with 48% (29 min/hr) of practice time in this analysis spent in MVPA. Also, in this study, participants spent over half of practice time sitting/lying, standing and in LIPA (6%, 28% and 18% respectively), which is consistent with previous studies that have identified large proportions of practice time spent in either sedentary or low intensity activities (Guagliano et al., 2013; Leek et al., 2011; Wickel and Eisenmann, 2007).

More recently, the PA levels of both a practice session and a game of a variety of different sports (soccer (Tomlin et al., 2015), ice hockey (van den Berg and Kolen, 2015), netball and basketball (Guagliano et al., 2013)) have been measured and compared. Across all sports studied, the amount of time spent in MVPA during practice sessions was significantly greater than during games (3-14% or 2-8mins). Interestingly, this contrasts with the findings of this analysis, which found that a significantly greater amount of time was spent in MVPA during games in comparison to practice sessions (12% or 7 min/hr). However, a number of methodological variations should be considered when comparing the PA levels attained during Gaelic football and other OS. Firstly, the lower amount of MVPA attained during practice sessions in Gaelic football may be a result of differences in the physiological demands. Research has previously demonstrated that significant differences in MVPA accumulation exist between a variety of sports, including soccer, netball, flag football, basketball and Australian Rules football (Ridley et al., 2018; Wickel and Eisenmann, 2007). Furthermore, this variation in time spent in MVPA may be attributable to age differences in the study samples, with the age range of the current analysis between 12-18 years, compared to 8-17 years in previous comparable research (Guagliano et al., 2013; Tomlin et al., 2015; van den Berg and Kolen, 2015). Indeed, Leek et al. revealed younger participants consistently accumulated significantly more time in MVPA during OS practice sessions when compared to older participants (Leek et al., 2011).

It should also be noted that the structure and content of practice sessions varies between contexts, such as differing situations of competition or times of the season (Cushion et al., 2012; Harvey et al., 2013). Recent research examining the practice sessions of Gaelic football coaches revealed that during preseason, the majority of practice time was spent in a traditional coaching approach, while a more game-based approach (GBA) was implemented in the regular season (Kinnerk et al., 2019). Cohen and colleagues demonstrated that youth MVPA levels during an OS practice session were significantly lower when coaches implemented traditional coaching approaches, in comparison to a GBA (Cohen et al., 2014b). Consequently, given data collection for this analysis was conducted during the preseason phase, this provides a possible explanation for the lower amount of time spent in MVPA during Gaelic football when compared to other OS.

The lower amount of MVPA accumulated during Gaelic football practice sessions in this study may be a result of the coaching style implemented, such as a tendency to overemphasize competition strategies or other non-active instruction, thereby limiting the amount of time that participants engage in MVPA (Kanters et al., 2015; Leek et al., 2011). Also, the greater amount of time spent in

MVPA during practice sessions in other sports may be due to the ability of coaches to better dictate the intensity of a practice session and the increased opportunity for players to participate simultaneously (Guagliano et al., 2013). Overall, given coaches have been identified as leaders in the youth OS setting (Schlechter et al., 2017), and carry influence over their players (Conroy and Coatsworth, 2006), they are in a position to impact the PA levels of participants (Howie et al., 2020). Over 50% of Gaelic football practice time was spent inactive or in low intensity activities, providing coaches with an opportunity to reallocate this time to MVPA. Indeed, Guagliano and colleagues demonstrated that a coach education program successfully increased time spent in MVPA in youth OS practice sessions by 15% and reduced practice time spent inactive by 14% (Guagliano et al., 2015). Miller et al. also highlighted that both MVPA and other OS outcomes, such as decision-making and skill execution, can be achieved simultaneously during OS practice sessions using a GBA (Miller et al., 2017). Evidently, coaches are capable of influencing PA intensity during practice sessions (Guagliano et al., 2015), and should be a central focus in future interventions and strategies to increase MVPA during OS.

A growing body of research has highlighted the importance of OS participation to the overall daily PA levels of adolescents. Indeed, OS participants have been shown to accumulate 5-20 minutes more MVPA daily (Hebert et al., 2015), and are 1.6-6.4 times more likely to achieve the recommended PA guidelines than their non-participating peers (Kokko et al., 2018; Mooses and Kull, 2019; Sprengeler et al., 2019). Moreover, an additional 7-25 minutes of MVPA is accumulated by OS participants on sports days in comparison to non-sports days (Koorts et al., 2019; Mooses and Kull, 2019; Sprengeler et al., 2019). In the current study, findings confirm that Gaelic football also provides an opportunity to accumulate time in MVPA, as participants were twice as likely to attain 60 minutes of MVPA on sports days than on non-sports days. However, despite attaining an average of 29-36 minutes of MVPA during Gaelic football participation, participants accumulated just an additional 16 minutes of MVPA on sports days when compared to non-sports days. These findings appear consistent with the concept of PA compensation, which theorizes that increased PA at one time point will result in decreased PA at another time point (Gomersall et al., 2013). This concept could have potential implications for interventions aimed at increasing PA, as effectiveness may be negated by decreases in PA at other time points, thus having minimal effect on overall daily PA levels (Metcalf et al., 2012; Ridgers et al., 2017). However, the research examining the existence of PA compensation is conflicting, with some studies supporting the concept (Ridgers et al., 2017; Ridgers et al., 2014; Ridgers et al., 2015), whereas other studies have found no evidence (Baggett et al., 2010; Goodman et al., 2011; Long et al., 2013; Ridgers et al., 2018). Additionally, it is currently unknown whether this compensation occurs within-days, between-days or over a longer period of time (Huang and Wong, 2019). There is a need for further investigation into the potential compensatory effect of increased MVPA during practice and/or game settings on daily MVPA.

The overall daily average of MVPA accumulated by participants in this study (58.5 mins) is consistent with previous research, which reported adolescents attain 32-85 minutes of MVPA daily (Hebert et al., 2015; Koorts et al., 2019; Marques et al., 2016; Sprengeler et al., 2019). However, despite this, the percentage of participants that achieved the PA guidelines in this analysis ranged from 6-31%, depending on which guidelines approach was used. Similarly, other research has also observed that 20-28% of OS participating youth achieved the PA guidelines (Telford et al., 2016; Vella et al., 2016), suggesting that OS alone does not provide sufficient amounts of MVPA to meet the guidelines (Guagliano et al., 2013; Ridley et al., 2018). Consistent with previous studies, gender differences were apparent, with males accumulating significantly more time in MVPA daily (Hebert et al., 2015), and achieving the PA guidelines more often than females (Marques et al., 2016; Telford et al., 2016), while daily MVPA levels decreased as age increased, which supports previous findings around age related PA (Corder et al., 2015; Harding et al., 2015). The low proportions of youth achieving the PA guidelines is of public health significance within Ireland, with reports currently estimating that physical inactivity has a direct economic cost of €132 million annually (Ding et al., 2016). Given the importance of PA for health maintenance and disease prevention in adolescents (Poitras et al., 2016), and the substantial effect this will have in adulthood (Hallal et al., 2006), a greater emphasis must be placed on increasing these low levels of Gaelic football participating youth achieving the PA guidelines.

It has been recently established that VPA has a stronger effect than lower intensity activities on health outcomes, including adiposity, cardiovascular fitness and bone health (Gralla et al., 2019; Owens et al., 2017). OS has also been identified as a supportive setting for youth to accumulate VPA (Guagliano et al., 2015; Schlechter et al., 2017). In this analysis, on average, participants accumulated significantly more time in VPA on sports days than on non-sports days and spent a larger percentage of both practice and game time in VPA in comparison to LIPA and MPA. Although the new WHO guidelines include an added recommendation that adolescents achieve VPA at least 3 times per week, these guidelines do not provide a recommendation on the specific amount of VPA to be accumulated (World Health Organisation, 2020). The absence of such guidelines may result in youth that achieve a sufficiently high level of health enhancing VPA (i.e. over a specified threshold of VPA in a measured week, as are available in adult populations) but insufficient levels of MVPA (either 60 minutes on every day of the week or an average of 60 minutes over the measurement period) to be mis-categorized as physically inactive. The use of such guidelines may have a significant impact on the proportion of youth that are categorized as attaining the PA guidelines and may provide a more accurate picture of the impact that OS is having on PA in youth.

A few potential limitations to the current study should be considered when interpreting the results. Firstly, due to the convenience sampling method used and the small number of Gaelic football teams investigated, there is the potential for sampling bias. Consequently, the results

obtained may not be representative of the wider population of youth Gaelic football teams and participants. However, this study tried to address these issues through the recruitment of participants from Gaelic football clubs that were in both rural and urban areas and from different socio-economic settings. Secondly, the PA findings presented were measured during the preseason phase of the youth Gaelic football calendar and may not be representative of the entire youth Gaelic football season. Lastly, due to the low numbers of active players in the clubs, only fifteen participants were recruited from the under 18 female group. This should be taken into account when examining the differences in PA levels across sex. Despite these limitations, the merits of this study should be considered. To the author's knowledge, this is the first study to use a device-based measure to record PA data in a youth Gaelic football setting. Finally, this is the first study that has examined the full range of PA intensities and body posture, using the activPAL^{3M} activity monitor, providing data on time spent sitting/lying, standing and in LIPA, MPA, VPA and MVPA when investigating youth in a Gaelic football setting.

Conclusion

Participation in youth Gaelic football provides a setting for adolescents to accumulate MVPA, however, the amount of MVPA attained was not enough to achieve the minimum PA guidelines. Over half of Gaelic football practice time was spent in sitting/lying, standing and LIPA, presenting an opportunity to increase time spent in MVPA. Future research should utilize this information in the development of coaching approaches and interventions to increase the amount of MVPA attained by adolescents during Gaelic football, thus enhancing the contribution of the sport to overall daily MVPA levels.

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Key points

- Participation in youth Gaelic football provides an opportunity for adolescents to accumulate MVPA.
- Gaelic football participation alone is not sufficient for adolescents to meet the MVPA recommendations.
- Over half of Gaelic football practice time was spent in sitting/lying, standing and LIPA, presenting an opportunity to increase time spent in MVPA.

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