Carter, S. E., Beaumont, A. J., & Sorbie, G. G. (2023). Physical Activity Accrued Whilst Golf Caddying. *International Journal of Golf Science*, *Volum 11*(Issue 1).

PUBLISHED PAPERS

Physical Activity Accrued Whilst Golf Caddying

Sophie E. Carter, Alexander J. Beaumont, Graeme G. Sorbie

Keywords: Golf, Caddy, Physical activity, Step count, Energy expenditure

International Journal of Golf Science

Vol. Volum 11, Issue Issue 1, 2023

Golf caddies are involved in golf at all levels of the game; however, little research has considered the physical activity (PA) accrued working in this profession. Importantly, the PA from playing golf can improve aspects of health; therefore, caddying may provide a PA that elicits similar benefits. This study, therefore, assessed the PA accrued whilst golf caddying. Eleven male caddies wore a PA monitor for 7-days and recorded time spent caddying while walking the 18-hole course at Carnoustie Golf Links, Scotland. Per day, caddies spent 224 minutes (58%) of their time caddying in light-intensity PA and 115 minutes (30%) of their time caddying in moderate-to-vigorous PA, accumulating 15480±4089 steps. Caddying accumulates enough moderate-to-vigorous PA across a week to exceed current PA guidelines, and the step count accrued is classified as highly active. Caddying can provide PA that has the potential to provide health benefits.

INTRODUCTION

In the sport of golf, a golf caddy is an individual who completes a supporting role alongside the golfer (Pilgrim et al., 2016). Whilst not playing the round of golf themselves, caddies complete many important roles including: carrying a golfer's bag and clubs, providing strategic support, course maintenance (such as raking bunkers and replacing the flag stick), and psychological support (Adams et al., 2020; Carey et al., 2021; Pilgrim et al., 2016). This role is completed globally at all levels of the game, from recreational to professional (Adams et al., 2020; Sorbie et al., 2022). For example, at Carnoustie Golf Links in the United Kingdom, during the 2022/2023 season, 67.4% (15,153 rounds) of rounds completed by non-members were with a caddy, and this value has increased from 57.4% (10,409 rounds) in 2018/2019. Despite the importance of a golf caddy, little research has explored the occupational demands of this profession, such as the physical job demands and the health benefits this may provide (Adams et al., 2020; Sorbie et al., 2022).

For most populations, participation in golf can provide moderate physical activity (PA) which can be sufficient to attain recommended PA guidelines (Luscombe et al., 2017; Murray et al., 2017). For example, an 18-hole round of golf enables participants to accumulate more than 10,000 steps (Kobriger et al., 2006), and general golf has a metabolic equivalent (METs) of 4.8 (Ainsworth et al., 2011). Golf, therefore, has the potential to provide a range of benefits to health. Indeed, a recent systematic review found golf participation to be effective for improving musculoskeletal, metabolic and cardiovascular health (Sorbie et al., 2022). Caddying, despite not involving playing the sport of golf specifically, may also allow individuals to attain moderate activity levels and by extension, benefit health; however, the activity accrued whilst golf caddying has received little research attention (Adams et al., 2020). In a small sample of female caddies, it was reported that they typically walked ~20,000 steps per round of golf (Goto et al., 2001); however, the intensity of this PA is unknown. A systematic review found few studies have considered the health effects of caddying, but in those that did, improvements in bone mineral density, lower limb strength, and Achilles tendon stiffness were reported (Sorbie et al., 2022).

Understanding the PA that golf caddying provides will enable research to be focussed on potential health benefits, but also provide considerations for employers regarding the demands of this form of employment. Information concerning the job demands can help inform specific workplace health intervention strategies for this population, improving job performance and reducing health hazards (Adams et al., 2020). The aim of this study was therefore to assess the PA accrued whilst golf caddying.

METHODS

Participants

A total of 11, male golf caddies (10 full-time, 1 part-time) volunteered, and written informed consent was obtained prior to inclusion. To be included, participants had to be aged 18 years or over. Demographic data for age, stature and body mass were obtained from each participant. In minimal clothing and without socks and shoes, body mass was measured to the nearest 0.1 kg using an electronic scale (Tanita SC-330ST Body Composition Analyser, Amsterdam, The Netherlands), whilst stature was measured using a wall stadiometer (Seca, Hamburg, Germany). Body mass index (BMI) was subsequently calculated (mass/stature^2).

Study Procedures

Participants were given an activity monitor to measure their PA and sedentary behaviour, and a wear-time log to complete. Following this, participants wore the monitors for the next seven consecutive days. After this period, participants returned the monitors to the research team in-person. Study procedures were approved by the Abertay University, School of Applied Sciences Ethics Committee.

Golf Caddying

All caddying rounds were completed on the 18-hole Championship Course at Carnoustie Golf Links, Angus, Scotland, United Kingdom; which has an approximate yardage of 6139 yards (depending on tee position). Data were collected during July 2022. Participants were required to log the time that they started and finished each 18-hole round of caddying, in addition to the weight of the golf bag they caddied. The golf bag was weighed by placing the bottom of the bag on a set of digital scales (Seca, Birmingham, UK), in an upright position. Caddying rounds that were completed using a golf buggy were excluded.

Physical Activity, Sedentary Behaviour and Energy Expenditure

PA, sedentary behaviour and activity energy expenditure (AEE) were measured using an ActiGraph wGT3X-BT tri-axial accelerometer (ActiGraph, Pensacola, Florida, USA). Each accelerometer was initialised using a 30 Hz

Table 1. Participant descriptive characteristics (n=11).

	Mean±SD or n(%) of Group
Male	11(100)
Age (years)	58 ± 8
Body mass (kg)	86.5 ± 11.9
Stature (cm)	176.5 ± 3.7
Body mass index (kg·m^2)	27.7 ± 3.0

sampling frequency (Brønd & Arvidsson, 2016). During each monitoring period, for seven consecutive days, participants wore the accelerometer on an elastic waist belt positioned on the right hip. They were instructed to wear the monitor during all waking hours, removing only for water-based activities such as showering. Participants were instructed to complete a log sheet detailing the times that the monitor was removed and replaced each day.

Data were downloaded at 60 second epochs and analysed using ActiLife software (Version 6.13.4, ActiGraph). Raw accelerometery data were presented in counts per minute (counts·min^{-1}). Non-wear time was defined as 90 consecutive minutes of zero counts·min^{-1} (Choi et al., 2011), and this was excluded from all analyses. PA intensity were determined using the cut points: light-intensity (≤2689 counts·min^{-1}), moderate-intensity (≤6166 counts·min^{-1}), and vigorous-intensity (>6167 counts·min^{-1}); which are validated cut points for healthy, normal or overweight adults (Sasaki et al., 2011). Time spent in moderate-to-vigorous PA (MVPA) was determined by summing the time engaged in moderate and vigorous PA, whilst total PA time was calculated by summing the time spent engaged in light, moderate and vigorous PA. Sedentary behaviour was defined using the cut point ≤200 counts·min^{-1} (Aguilar-Farías et al., 2014). AEE was calculated using the Freedson VM3 Combination algorithm from the vector magnitude counts per minute of the three axes (Sasaki et al., 2011). Participants' data were only included for analyses if the following criteria were met: ≥10 hours of wear time per day, for a minimum of four days, including one weekend day (Trost et al., 2005). Participants' log-book records of their caddying hours were used to determine time spent caddying. By applying filters in the ActiLife software to correspond to these reported hours, activity intensities were calculated for caddying for each day.

RESULTS

Participants

A sample of 11 male caddies completed the study. Descriptive characteristics are shown in Table 1.

Table 2. Device-measured physical activity (PA) and sedentary time of participants whilst caddying (n=11; mean±SD).

	Time (minutes)	% of Caddying Time
Sedentary	45±46	12±12
Light-intensity PA	224±53	58±9
Moderate-intensity PA	111±28	29±7
Vigorous-intensity PA	4±6	1±2
MVPA	115±31	30±7
Total PA	339±69	88±12

PA- physical activity; MVPA- moderate-to-vigorous physical activity

Caddying

Participants reported caddying on 6 of the 7 days of monitoring, and completed a weekly average of 8 caddying rounds. Across the week, on average, participants spent a total of 38 hours and 13 minutes caddying, or an average of 5 hours 27 minutes per day. The mean weight of the golf bag carried was 11.7 ± 1.8 kg.

Physical Activity and Sedentary Behaviour

The mean daily step count during caddying was 15480 ± 4089 steps. The mean time spent in different PA intensities and sedentary behaviour per day are shown in Table 2. When caddying, participants on average spent 224 ± 53 minutes of their time in light-intensity PA, 111 ± 28 minutes of their time in moderate-intensity PA, and 4 ± 6 minutes of their time in vigorous-intensity PA.

Activity Energy Expenditure

The AEE recorded during caddying was 2.4 ± 0.4 METs with a calorific expenditure of 2.7 ± 0.6 kcals·min.

DISCUSSION

The aim of this study was to assess the PA accrued whilst golf caddying. Main findings suggest that whilst caddying, caddies spent 339 minutes engaged in PA, of which 115 minutes (30% of time) was spent in MVPA. This is of notable importance since current World Health Organisation PA guidelines for adults recommend a minimum of 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity, or an equivalent combination of MVPA, per week to confer health benefits (Bull et al., 2020). Since caddies reported caddying on average 6 days a week, their weekly PA far exceeds this minimum recommended value. These data, therefore, suggest that caddying enables individuals to meet PA minimum guidelines, as has been reported for playing golf (Luscombe et al., 2017; Murray et al., 2017). The PA from golf participation can enhance aspects of health (Murray et al., 2017; Sorbie et al., 2022), therefore, future research should investigate whether the PA accrued during caddying can also improve health domains.

During each day of caddying, an average of 15,480 steps were accumulated. This is similar to the 11,245 to 16,667 steps accrued whilst playing 18 holes of golf (Murray et al., 2017), but lower than the 20,499 steps reported in the only study measuring step count in female caddies (Goto et al., 2001). A possible explanation for this disparity may relate to sex, since higher step counts are accumulated by females when playing golf compared to males (Luscombe et al., 2017). Sex-based differences may, therefore, also be present for caddies' step counts. The step count accrued whilst caddying exceeds commonly reported daily targets of 10,000 steps (Kobriger et al., 2006), and classifies individuals as highly active (Tudor-Locke et al., 2008). Collectively, the step count and PA intensity data reported in this study provide important information regarding the work demands of caddying, demonstrating that it is a highly active profession. These data provide initial findings that, in the long term, may help towards developing workplace health intervention strategies for this population in order to improve job performance and reduce health risks (Adams et al., 2020).

Caddying had a METs value of 2.4, which is lower than the reported 4.8 METs for general golf from the Compendium of Physical Activities (Ainsworth et al., 2011). In a review of the PA accrued whilst playing golf, however, a range of 2.1-8.6 METs was reported, indicating that this value can be highly variable depending on factors such as course profile, method of club transportation, and individual characteristics such as sex (Luscombe et al., 2017). Furthermore, since caddying does not involve performing a golf swing, this likely accounts for the lower METs. Indeed, a full golf swing is a high intensity activity, resulting in near maximal muscular contractions, and occurs 30-40 times per golf round (Evans & Tuttle, 2015). In this study, caddies also spent 58.2% of caddying time in light-intensity PA and, in contrast, as much as 60% of a golfer's time is spent preparing and performing swings (Evans & Tuttle, 2015). Collectively, this is likely to also support the lower calorific AEE reported for caddying (2.7 kcals·min) when compared to the range of 5.2-8.25 kcal·min reported when playing golf (Luscombe et al., 2017). It is important to note that when considering METs and AEE, direct comparisons between studies is challenging due to methodological differences and, therefore, future research should seek to adopt standardised methods.

Limitations

The study cohort included a small sample of male caddies working at one Links golf course in Scotland, thus representing a specific caddy population. For golfers, PA levels differ due to the course profile and sex (Luscombe et al., 2017; Murray et al., 2017). Future studies should, therefore, incorporate additional golf courses and include a larger sample of male and female caddies in order to explore the influence that sex and course architectural designs and profiles have on the PA levels of caddying. Whilst this study is strengthened by the use of a device-based method to measure PA and sedentary time, accelerometers do not measure posture, meaning standing time can be misclassified as a sedentary behaviour (Clemes et al., 2014). It is therefore possible that standing time when caddying may have contributed to total sedentary time, leading to an overestimation of this value. Future research should aim to use inclinometers, which are able to discern between standing and sedentary activities. The cut points used to classify PA intensities were not population-specific, which can influence PA outcomes since cut points are derived from the calibration sample (Gao et al., 2021; Rowlands et al., 2018). Cut points specific to a caddy population have not been created, therefore, cut points derived from a healthy adult population were adopted to as best possible represent this sample. The gold standard method for measuring free-living EE (doubly labelled water) was not conducted (Guediri et al., 2021). Furthermore, when calculating AEE, the weight of the golf bag was not accounted for, since this was not carried continuously during each round. This may mean that AEE values are underestimated. Similarly, body mass was acquired 12 weeks prior to the collection of PA data, and whilst it is possible that fluctuations in body mass may have occurred during this time, other external variables such as hydration status and golf bag mass add variability to this. Additionally, the AEE and METs classification would require precise timing of when the bag is carried during a round, which may be more feasibly assessed with heart rate analysis during the round, as previously used when measuring AEE whilst playing golf (Kasper et al., 2022). Furthermore, the use of accelerometery to assess AEE has known limitations including caution regarding the accuracy of values, and the assessment of AEE rather than total EE (Guediri et al., 2021; Migueles et al., 2017); however, this is the first study to objectively assess AEE in caddies and future studies should seek to use alternative methodologies.

Conclusion

Golf caddying allows individuals to achieve similar PA levels to playing golf. Caddying accumulates enough moderate-to-vigorous PA across a week to exceed current PA minimum guidelines, and the daily step count accrued is classified as being highly active. As has been reported for golf participation, caddying, therefore, has the potential to provide health benefits to individuals, which future research should explore. Data also provide initial evidence to help characterise the job demands of caddying, which may help inform workplace health intervention strategies for this population.

ACKNOWLEDGEMENTS

Thank you to Carnoustie Golf Links for the help and support throughout the study.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

FUNDING

This study was supported by the R-LINCS Pump Priming Fund at Abertay University.

Submitted: February 08, 2023 BST, Accepted: April 04, 2023 BST

References

Adams, K. J., Sevene, T., Walsh, J., Climstein, M., & DeBeliso, M. (2020). The golf caddie - The forgotten worker. *Journal of Physical Activity Research*, *5*(1), 41–44. https://doi.org/10.12691/jpar-5-1-8

Aguilar-Farías, N., Brown, W. J., & Peeters, G. M. E. E. (2014). ActiGraph GT3X+ cut-points for identifying sedentary behaviour in older adults in free-living environments. *Journal of Science and Medicine in Sport*, *17*(3), 293–299. https://doi.org/10.1016/j.jsams.2013.07.002

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Bassett, D. R., Tudor-Locke, C., Greer, J. L., Vezina, J., Whitt-Glover, M. C., & Leon, A. S. (2011). 2011 compendium of physical activities: A second update of codes and MET values. *Medicine & Science in Sports & Exercise*, *43*(8), 1575–1581. https://doi.org/10.1249/mss.0b013e31821ece12

Brønd, J. C., & Arvidsson, D. (2016). Sampling frequency affects the processing of ActiGraph raw acceleration data to activity counts. *Journal of Applied Physiology*, *120*(3), 362–369. https://doi.org/10.1152/japplphysiol.00628.2015

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., Dipietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., ... Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Carey, L. M., Stone, J. A., & Lavallee, D. (2021). "Teamwork Done to a Tee": A golf caddie's perspective on their perceived role and associated skills. *International Journal of Golf Science*, *9*, 2021.

Choi, L., Liu, Z., Matthews, C. E., & Buchowski, M. S. (2011). Validation of accelerometer wear and nonwear time classification algorithm. *Medicine & Science in Sports & Exercise*, *43*(2), 357–364. https://doi.org/10.1249/mss.0b013e3181ed61a3

Clemes, S. A., O'Connell, S. E., & Edwardson, C. L. (2014). Office workers objectively measured sedentary behavior and physical activity during and outside working hours. *Journal of Occupational & Environmental Medicine*, *56*(3), 298–303. https://doi.org/10.1097/jom.0000000000000101

Evans, K., & Tuttle, N. (2015). Improving performance in golf: Current research and implications from a clinical perspective. *Brazilian Journal of Physical Therapy*, *19*(5), 381–389. https://doi.org/10.1590/bjpt-rbf.2014.0122

Gao, Z., Liu, W., McDonough, D. J., Zeng, N., & Lee, J. E. (2021). The dilemma of analyzing physical activity and sedentary behavior with wrist accelerometer data: Challenges and opportunities. *Journal of Clinical Medicine*, *10*(24), 5951. https://doi.org/10.3390/jcm10245951

Goto, S., Ishima, M., Shimizu, M., Kobayashi, Y., & Moriya, H. (2001). A longitudinal study for femoral neck bone mineral density increases in premenopausal caddies using dual-energy X-ray absorptiometry. *Journal of Bone and Mineral Metabolism*, *19*(2), 125–130. https://doi.org/10.1007/s007740170051

Guediri, A., Robin, L., Lacroix, J., Aubourg, T., Vuillerme, N., & Mandigout, S. (2021). Comparison of energy expenditure assessed using wrist- and hip-worn ActiGraph GT3X in free-living conditions in young and older adults. *Frontiers in Medicine*, *8*, 1–9. https://doi.org/10.3389/fmed.2021.696968

Kasper, A. M., O'Donnell, A., Langan-Evans, C., Jones, A., Lindsay, A., Murray, A., & Close, G. L. (2022). Assessment of activity energy expenditure during competitive golf: The effects of bag carrying, electric or manual trolleys. *European Journal of Sport Science*, *23*(3), 330–337. https://doi.org/10.1080/17461391.2022.2036817

Kobriger, S. L., Smith, J., Hollman, J. H., & Smith, A. M. (2006). The contribution of golf to daily physical activity recommendations: How many steps does it take to complete a round of golf? *Mayo Clinic Proceedings*, *81*(8), 1041–1043. https://doi.org/10.4065/81.8.1041

Luscombe, J., Murray, A. D., Jenkins, E., & Archibald, D. (2017). A rapid review to identify physical activity accrued while playing golf. *BMJ Open*, *7*(11), 1–9. https://doi.org/10.1136/bmjopen-2017-018993

Migueles, J. H., Cadenas-Sanchez, C., Ekelund, U., Delisle Nyström, C., Mora-Gonzalez, J., Löf, M., Labayen, I., Ruiz, J. R., & Ortega, F. B. (2017). Accelerometer data collection and processing criteria to assess physical activity and other outcomes: A systematic review and practical considerations. *Sports Medicine*, *47*(9), 1821–1845. https://doi.org/10.1007/s40279-017-0716-0

Murray, A. D., Daines, L., Archibald, D., Hawkes, R. A., Schiphorst, C., Kelly, P., Grant, L., & Mutrie, N. (2017). The relationships between golf and health: A scoping review. *British Journal of Sports Medicine*, *51*(1), 12–19. https://doi.org/10.1136/bjsports-2016-096625

Pilgrim, J., Robertson, S., & Kremer, P. (2016). A qualitative investigation into the role of the caddie in elite-level golf. *International Journal of Sports Science & Coaching*, *11*(4), 599–609. https://doi.org/10.1177/1747954116654783

Rowlands, A. V., Edwardson, C. L., Davies, M. J., Khunti, K., Harrington, D. M., & Yates, T. (2018). Beyond cut points: Accelerometer metrics that capture the physical activity profile. *Medicine & Science in Sports & Exercise*, *50*(6), 1323–1332. https://doi.org/10.1249/mss.0000000000001561

Sasaki, J. E., John, D., & Freedson, P. S. (2011). Validation and comparison of ActiGraph activity monitors. *Journal of Science and Medicine in Sport*, *14*(5), 411–416. https://doi.org/10.1016/j.jsams.2011.04.003

Sorbie, G. G., Beaumont, A. J., Williams, A. K., & Lavallee, D. (2022). Golf and physical health: A systematic review. *Sports Medicine*, *52*(12), 2943–2963. https://doi.org/10.1007/s40279-022-01732-w

Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine & Science in Sports & Exercise*, *37*(11 Suppl.), 531–543. https://doi.org/10.1249/01.mss.0000185657.86065.98

Tudor-Locke, C., Hatano, Y., Pangrazi, R. P., & Kang, M. (2008). Revisiting "how many steps are enough?" *Medicine & Science in Sports & Exercise*, *40*(7 Suppl 1), 537–543. https://doi.org/10.1249/mss.0b013e31817c7133