



Original research

Sex-based differences in the external loads imposed during an official Ultimate-Frisbee competition: A Pilot Study

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Abstract: The increase in the number of participants of Ultimate Frisbee suggest the necessity to improve the knowledge about this sport and its demands. Thus, the aim of this study was to quantify and compare the external loads imposed upon players during official Ultimate Frisbee matches according to sex. Twelve male and female players participated in four official Ultimate Frisbee matches. Players were divided according to sex (8 males and 4 females). The average duration of matches was 62.3 ± 13.8 min, during which the players were active for 34.9 ± 11.4 min. External loads (i.e., total distance covered, distance covered at different speeds, accelerations and decelerations) encountered by Ultimate Frisbee players were compared between sexes (males vs females). Male players registered greater external loads ($p < 0.05$ large-moderate), especially performing high-intensity actions [distance at high intensity (827 ± 275 m), distance at very-high speeds (110 ± 82 m), and medium-high accelerations (474 ± 176 m and 118 ± 84 m respectively) and decelerations (218 ± 80 m and 74 ± 42 m respectively)] than female players (556 ± 191 m, 6 ± 9 m, 360 ± 160 m, 31 ± 32 m, 156 ± 73 m and 38 ± 25 m, respectively). Coaching and performance staff should consider the sex of each player when developing training programmes and tactical strategies to optimise player performance during Ultimate Frisbee matches.

Keywords: physical demands; GPS, high-intensity actions; accelerations; decelerations.

1. Introduction

Ultimate Frisbee is a non-contact, team sport developed in 1967 (Marfleet, 1991), which has experienced high growth in recent years (Krustrup & Mohr, 2015). Specifically, Ultimate Frisbee is one of the most popular events at the World Games (The World, 2017). Ultimate Frisbee is played by millions of people across approximately 50 countries (Griggs, 2009), with high participation particularly in the United States of America (Akinbola et al., 2015). In this sense, an estimated 848,000 people play Ultimate

Frisbee at least 25 times each year in the United States of America (Yen et al., 2010). Ultimate Frisbee is played by all ages in male, female, and mixed-sex competitions (Griggs, 2009; Madueno et al., 2017; Scanlan et al., 2015). Ultimate Frisbee is typically played on an 100 x 60 m outdoor pitch with seven players a side (Krustrup & Mohr, 2015), and the main objective is to score goals by catching a plastic disc in the attacking end-zone (Madueno et al., 2017). Matches can be time-bound (2 x 30-min halves) or score-bound (first team to score 15 points is declared the winner) (WFDF, 2016). Players are not permitted to run in possession of the



disc, but may pivot and pass to their teammates within 10 seconds of catching the disc (Lazar et al., 2018).

Given the unique activity requirements in Ultimate Frisbee and the varied match formats comprising different sexes, it is important to ensure sport-specific training programs and recovery approaches to optimize player health and performance. In order to make evidence-based decisions regarding training and recovery practices in Ultimate Frisbee, it is first important to understand the match demands of the sport. However, limited research has quantified the external loads completed by players during Ultimate Frisbee matches (Krustrup & Mohr, 2015; Madueno et al., 2017), and both studies obtained the total distance covered differently (i.e., a single match vs. the mean of four modified matches). To date, it has been shown male players cover a total distance of 4700 ± 470 m, with 3490 ± 350 m covered performing low-intensity running ($0-13.9$ km·h⁻¹), 630 ± 140 m performing high-intensity running ($14-22$ km·h⁻¹), and 210 ± 110 m sprinting (>22 km·h⁻¹) during Ultimate Frisbee matches (Krustrup & Mohr, 2015). On the other hand, Madueno et al. (2017) observed that male players covered a total distance of 2949 ± 519 m during four modified matches. Less data are available for female players with research demonstrating 2935 ± 500 m are covered during Ultimate Frisbee matches (Madueno et al., 2017). However, it should be noted the research examining female players analysed modified matches, which are not indicative of actual competition (18-min halves on a 60 x 30-m pitch) and distance was not directly measured but instead estimated using a proprietary calculation method based on accelerometer data. Therefore, the external loadings imposed upon female players are largely unknown. Furthermore, no data are available indicating the external demands encountered during mixed-sex Ultimate Frisbee matches. In addition to these limitations, much of the external load data reported during Ultimate Frisbee matches encompasses total distance or distances covered in specific intensity zones.

Consequently, important external loading related to accelerations and decelerations are yet to be provided during Ultimate Frisbee matches.

Similar to other team-sports, Ultimate Frisbee requirements include high-effort actions interspersed with low intensity recovery, changes of directions, and sudden high-intensity accelerations and decelerations (Madueno et al., 2017). Although not analysed in previous research, all these actions have been linked to most team-sport performance, and therefore, it can be hypothesized that play a role in ultimate frisbee success. In this regard, short-term high-intensity actions, such as accelerations and decelerations, seem to be crucial to performance in team sports (Delaney et al., 2017; Russell et al., 2016). Specifically, decisive actions such as contesting for the ball in one-on-one situations occur in spaces of less than 10 m² during matches, emphasising the importance of acceleration and deceleration capacities to achieve success (Mara et al., 2017). Additionally, a greater acceleration capacity has been significantly associated with distance covered at high intensities during female Australia Rules football matches ($r = -0.612$, $p < 0.05$) (Black et al., 2018). Therefore, an examination of the external loading during Ultimate Frisbee matches should encompass short-term, high-intensity actions such as accelerations and decelerations.

The main aim of this study was to quantify and compare the external loads encountered during Ultimate Frisbee matches between players of different sexes. Based on data in other team sports comparing external loading between sexes (Bradley et al., 2014; Suarez-Arrones et al., 2015), we hypothesised male players will experience greater external loads than female players during Ultimate Frisbee matches.

2. Materials and Methods

Subjects

Twelve national-level Ultimate Frisbee players competing in an elite mixed-sex competition (age: 28.1 ± 5.3 years, height: 173.1 ± 7.0 cm, body mass: 71.1 ± 12.0 kg and body mass index (BMI) 23.4 ± 2.6 kg·m⁻²), participated in the study. Players were divided according to sex [male (n = 8): age: 28.6 ± 5.6 years, height: 178.2 ± 4.6 cm, body mass: 76.1 ± 11.3 kg and BMI 24.0 ± 2.9 kg·m⁻²; female (n = 4): age: 27.0 ± 5.1 years, height: 165.2 ± 4.3 cm, body mass: 61.0 ± 5.4 kg and BMI 22.2 ± 1.5 kg·m⁻²). Players trained 3 times per week (1.5 hours per session) and have 5 ± 3 years of experience in Ultimate Frisbee. All players competing in at least 80% (50.2 ± 11.1 min) of total match time were selected for further analysis, and according to this, six male and 4 female players were discarded in the analysis of some match. In addition, players were informed of the objectives of the research, participated voluntarily and had the possibility to withdraw at any time from the investigation without any penalty. All the players signed an informed consent prior to the start of the investigation. The study was performed in accordance with the Declaration of Helsinki (2013), approved by the Ethics Committee of University of Isabel I and met the ethical standards for sport and exercise science research (Harriss & Atkinson, 2015).

Methodology

External loads imposed upon Ultimate Frisbee players were collected during four official matches in a mixed-sex Ultimate Frisbee competition across two consecutive days. In the 48-hour period before the matches, players did not perform any strenuous physical exercise, and the participants were given advice to ensure they were fully hydrated upon the commencement of each match. In addition, all players had not reported any injuries throughout the 2 months before the matches. The playing pitch consisted of an outdoor, natural, grass surface, spanning 100 m (including 2 x 15-m end zones) in length x 60 m in width.

Ultimate Frisbee matches. The official matches consisted of 2 x 30-min halves with a 5-min rest period between halves. However, when full-time was reached, play continued until a team scored as per the rules of the sport (Krustrup & Mohr, 2015). The average duration of matches was 62.3 ± 13.8 min, during which the players were active for 34.9 ± 11.4 min, and the remaining 27.4 ± 10.2 min was accounted for by breaks (no activity) between points, referee discussions and substitutions.

An official referee tabulated the score and ensured rules were followed. During each point, the same number of male and female players was in each team. Prior to each match, players undertook a 20-min standardized warm-up, consisting of slow jogging, strolling locomotion and dynamic stretches followed by more sport-specific exercises (e.g., different passes in groups) and finishing with progressive sprints and accelerations.

External loads. External loading was monitored for each player in all matches using microsensor units containing a 10-Hz global positioning system (WIMU PROTM, RealTrack Systems, Almería, Spain) (Bastida Castillo et al., 2018). Microsensor units were harnessed in a tight-fitting vest worn by the players throughout matches. The microsensor units were activated 15 min before the start of each match, in accordance with the manufacturer's recommendations. Data were downloaded post-match to a computer and analysed using a customised software package (WIMU SPRO, Almería, Spain). The total distance covered was taken as a key outcome measure with further distance measures derived for different locomotive categories: low-intensity walking (<3.9 km·h⁻¹), walking (4.0-7.9 km·h⁻¹), jogging (8.0-13.9 km·h⁻¹), high-intensity running (>14.0 km·h⁻¹), and high-speed running (>22.0 km·h⁻¹) (Raya-González et al., 2020). Also, distance covered while accelerating and decelerating was also determined for different intensity categories: low-intensity acceleration (LACC; 1.0-2.5 m·s⁻²), medium-intensity acceleration

(MACC; 2.5-4.0 m·s⁻²), high-intensity acceleration (HACC; >4.0 m·s⁻²), low-intensity deceleration (LDEC; -1.0/-2.5 m·s⁻²), medium-intensity deceleration (MDEC; -2.5/-4.0 m·s⁻²), and high-intensity deceleration (HDEC; <-4.0 m·s⁻²) (Raya-González et al., 2020). The validity and reliability of the WIMU microsensor units for the measurement of total distance, as well as distance covered during low-intensity walking, walking, jogging, high-intensity running, high-speed running, LACC, MACC, HACC, LDEC, MDEC and HDEC have been supported elsewhere (Hernández-Belmonte et al., 2018).

Statistical Analysis

Results are presented as mean ± standard deviations (SD). Normal distribution and homogeneity of variances was confirmed with the Kolmogorov-Smirnov and Levene tests. A t-test for independent samples was used to analyze the differences on external responses between males and females Ultimate Frisbee players. Effect sizes (ES) with uncertainty of the estimates shown as 90% confidence limits (CL) were used to quantify the magnitude of the difference

between sexes. The ES were classified as trivial (< 0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), very large (2.0–4.0) and extremely large (>4.0) (Hopkins et al., 2009). Data analysis was performed using the Statistical Package for Social Sciences (version 21.0 for Windows, SPSS Inc, Chicago, IL, USA). The level of significance was set at $p < 0.05$.

3. Results

The external loads measured according to sex during standard matches (2 x 30-min halves) are presented in Table 1. Male players covered greater distances at high-intensity and high-speed intensities ($p < 0.05$ moderate-large, Figure 1) and higher distances at medium and high accelerations and decelerations ($p < 0.05$ moderate, Figure 2) than female players.

Table 1. The external loads (mean ± SD) encountered during official Ultimate Frisbee matches according to sex and playing position with mean differences.

| Variables | Males (n = 26) | percentage of total | Females (n = 12) | percentage of total | Mean difference; ±90% CL |
|----------------------------|----------------|---------------------|------------------|---------------------|--------------------------|
| Total distance (m) | 4092 ± 960 | - | 3656 ± 1061 | - | -11.9; ±15.8 |
| Low-intensity walking (m) | 967 ± 233 | ≈ 23% | 874 ± 239 | ≈ 24% | -10.4; ±17.7 |
| Walking (m) | 1212 ± 343 | ≈ 29% | 1057 ± 375 | ≈ 29% | -14.7; ±19.7 |
| Jogging (m) | 1087 ± 389 | ≈ 26% | 1169 ± 471 | ≈ 32% | 7.4; ±29.7 |
| High-intensity running (m) | 827 ± 275 | ≈ 20% | 556 ± 191 | ≈ 15% | -33.4; ± 22.6 |
| High-speed running (m) | 110 ± 82 | ≈ 2% | 6 ± 9 | ≈ 0.1% | -89.5; ±14.1 |
| LACC (m) | 687 ± 211 | ≈ 48% | 696 ± 259 | ≈ 64% | -0.2; ±23.4 |
| MACC (m) | 474 ± 176 | ≈ 34% | 360 ± 160 | ≈ 33% | -27.8; ± 27.1 |
| HACC (m) | 118 ± 84 | ≈ 8% | 31 ± 32 | ≈ 3% | -82.3; ±17.5 |
| LDEC (m) | 487 ± 168 | ≈ 62% | 474 ± 161 | ≈ 71% | -1.8; ±24.3 |
| MDEC (m) | 218 ± 80 | ≈ 28% | 156 ± 73 | ≈ 23% | -33.4; ±25.3 |
| HDEC (m) | 74 ± 42 | ≈ 10% | 38 ± 25 | ≈ 6% | -51.7; ±34.7 |

n = number of observations overall and for each sex. CL = confident limits; SD = standard deviation. LACC = low-intensity acceleration between 1 and 2.5 m·s⁻². MACC = medium-intensity acceleration between 2.5 and 4 m·s⁻². HACC = high-intensity acceleration above 4 m·s⁻². LDEC = low-intensity deceleration between -2.5 and -1 m·s⁻². MDEC = medium-intensity deceleration between -4 and -2.5 m·s⁻². HDEC = high-intensity deceleration less than -4 m·s⁻².

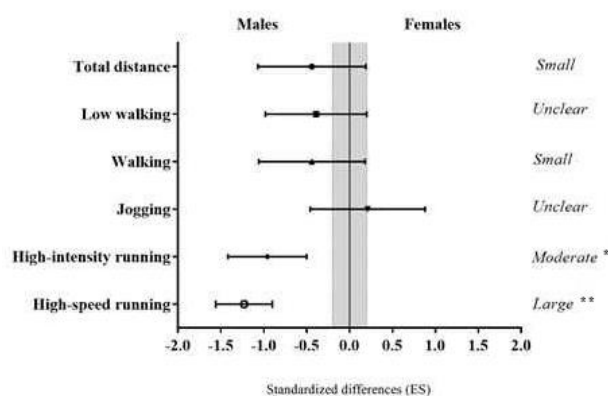


Figure 1. Differences between male and female players in the distances covered at different locomotive intensities during official Ultimate Frisbee matches.

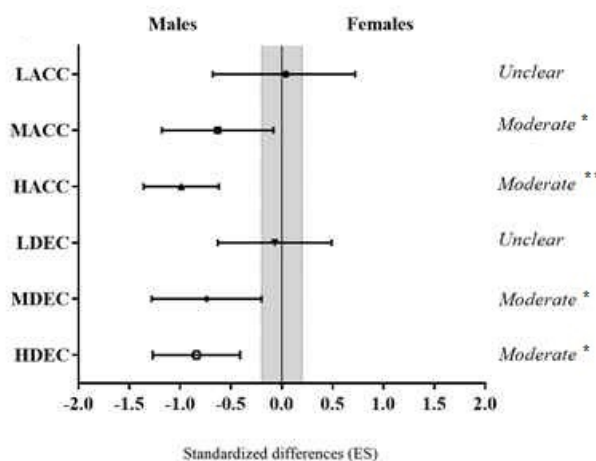


Figure 2. Differences between male and female players in the acceleration and deceleration intensities during official Ultimate Frisbee matches. LACC = low-intensity acceleration between 1 and 2.5 m·s⁻²; MACC = medium-intensity acceleration between 2.5 and 4 m·s⁻²

4. Discussion

The main aim of this study was to quantify and compare the external loads imposed upon Ultimate Frisbee players during matches according to sex. This is the first investigation to describe the external loads measured upon elite Ultimate Frisbee players, as well as during mixed-sex competition. The main results of the study showed males performed greater external loads, especially high-intensity actions (distance covered at high-intensity and high-speed running as well as medium-high

accelerations and decelerations) than females.

Despite being developed over 25 years ago (Marfleet, 1991) and accruing a large number of participants worldwide (Scanlan et al., 2015), only two studies have quantified the external loads encountered by players during Ultimate Frisbee matches (Krustrup & Mohr, 2015; Madueno et al., 2017). While some research has quantified the external loads imposed upon male Ultimate Frisbee players (Krustrup & Mohr, 2015) limited data are available for female players (Madueno et al., 2017) with no data reported during mixed-sex matches. More precisely, Madueno et al. (2017) examined recreational college players reporting male players to cover 2949 ± 519 m and female players to cover 2935 ± 500 m per match. While these data are considerably lower than the total distances presently observed according to sex (males: 4092 ± 960 m; females: 3656 ± 1061 m), differences between studies could be due to the modified rules adopted by Madueno et al. (2017) where matches consisted of 2 x 18-min halves on a reduced-size pitch (60 x 30 m). In addition, Madueno et al. (2017) examined recreational athletes likely possessing less training experience and reduced conditioning to the demands of Ultimate Frisbee than the elite players we recruited. However, the total distance observed in the present study for male players was lower than that previously reported in other research during official matches (4700 ± 470 m) (Krustrup & Mohr, 2015) with less high-speed running distances achieved (110 ± 82 m vs. 210 ± 110 m). These differences could be explained by the inclusion of only male matches in the study completed by Krustrup and Mohr (Krustrup & Mohr, 2015). Specifically, in elite team sports, female matches have been shown to elicit lower movement intensities than male matches (Bradley et al., 2014), which might have lower the “match pace” and restricted the total distance covered by male players during mixed-sex Ultimate Frisbee matches in our study. Nevertheless, the direct comparisons between sexes in the present study provide further insight into the precise

demands encountered during Ultimate Frisbee competition.

The present study provides novel data directly comparing the external loads encountered during mixed-sex Ultimate Frisbee competition between males and females. Although small differences were observed in total distance covered between male and female players, males covered greater distances (large-moderate) working at higher intensities (i.e., high-intensity running, high-speed running, MACC, HACC, MDEC and HDEC) during official matches. These findings contrast those reported by Madueno et al. (2017) who observed similar total distance measures across sexes during separate male and female matches. However, the total distance data reported by Madueno et al. (2017) were indicative of shortened matches (2 × 18-min halves) and measurements were predicated on accelerometer-based estimates without the added provision of movement distances according to intensity.

This study is not exempt of limitations. For instance, only four matches were examined across a 2-day period in the study. The congested nature of the matches may have influenced the external loads performed by players likely carrying residual levels of fatigue into subsequent matches. In this sense, it would be interesting to quantify temporal recovery responses in players 24–48 h following matches (Sparkes et al., 2018) as well as isolating the impact of competing under fatigue on external loads during Ultimate Frisbee (Coutinho et al., 2018). In addition, external demands were analysed using generic velocity threshold, obviating the individual velocity thresholds of each player. Finally, various contextual factors may have affected the match load encountered by players and have not been considered in this investigation, such as scoreline (Lago-Peñas, 2012), opposition quality (Castillo et al., 2018) or pitch surface (Pastore et al., 2017). Further research is encouraged examining the impact of these contextual match factors on the external loads of Ultimate Frisbee players, which may

be analysed using the individual velocity thresholds for each player.

5. Conclusions

The present study demonstrates sex influence the external loads (mainly high-intensity actions) experienced by players during mixed-sex Ultimate Frisbee matches. Current results indicate that coaching and performance staff of elite Ultimate Frisbee teams should consider the sex of each player in order to design the most sport-specific training programmes and recovery strategies to optimally prepare for competition. However, future studies performed with different teams are necessary.

Supplementary Materials: The following are available online at www.jsc-cycling.com/xxx, Figure S1: title, Table S1: title, Video S1: title.

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Conflicts of Interest: The authors declare no conflict of interest.

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