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Original Article

Analysis of internal and external loads in official ultimate frisbee competition: A comparison match performance outcome and playing position.

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Abstract:
In this study, we examined and compared internal and external loads during an official Ultimate Frisbee (UF) competition, focusing on match performance outcomes and playing positions. The research involved 56 UF players from 8 teams competing in mixed-gender championship Thailand. Each team comprised 4 male and 3 female players, and all participants were observed across 4 competitive matches, including the first round, quarterfinals, semifinals, and finals. The heart rate and distance covered in each speed zone were collected using Polar Team Pro™ throughout 4 official matches, After each match, athletes were separated for statistical analysis based on performance (winners vs. losers) and position (handler, cutter, and deeper positions). Data were analyzed using mean, standard deviation, independent t-test, and one-way ANOVA. All tests used the 0.05 level of significance. The results showed that for the winners, the HR (heart rate), % HR_{max}, distance covered, and number of sprints were higher (P<0.05) than for the losers; in addition, the winners spent more (*P*<0.05) time at high intensity and very high-intensity levels than the losers, as well as more (P<0.05) time doing high-speed running and sprinting than the losers. Comparing the playing positions in the match, the deeper was higher (P<0.05) than the handler and cutter positions, as well as spending more (*P*<0.05) time at high intensity, very high intensity, high-speed running and sprinting levels than the handler and cutter positions. The data from this study should be helpful for coaches and athletes for the development of a specific training program to improve the performance of UF players, which is an essential instrument in the modern planning and application of training loads.
Key Words: Physiological demand, Activity profile, athlete monitoring

Introduction

Ultimate Frisbee (UF), also known simply as “Ultimate**”,** is a fast-growing team sport worldwide and is considered an alternative, hybrid, non-contact sport as it contains rules indicative of more common team sports such as rugby, basketball, netball, and football. As UF continues to expand in popularity and become competitive, validated scientific data will be required to help advance the sport. Many elite and professional sports have substantial evidence-based knowledge on the demands of the game and optimal preparation strategies for the sport (Krustrup & Mohr, 2015) (Castellano et al., 2011).

Such information allows coaches and conditioning staff to develop training programs that meet the demands of the sport, ensuring players train specifically and effectively. A better understanding of the demands of game-play is important, with researchers having historically examined the internal and external demands imposed upon players in order to describe the dose-response profile in specific sports.

Despite the growing popularity of UF, there is only rather limited scientific knowledge regarding the internal and external demands of the game. There have only been a few scientific studies that have investigated UF players. One study showed that collegiate male UF players covered 4.7 km, which included ~600 m of high-intensity running (at 14–22 km/h) and ~200 m of sprinting (at above 22 km/h), with the levels for mean and peak intensity (% HRmax) during the UF game reaching 82% and 99% of HRmax respectively (Krustrup & Mohr, 2015). Castillo et al. (2020) reported that during a 36 min UF game, played by recreational male players (5 vs. 5), the mean HR and blood lactate concentration (BLa) were 88% HRmax, and 5.5 mmol/L, respectively. In an official national-level match, the peak sprinting velocity reportedly reached 26.0 km/h. Furthermore, recreational male and female players undergo high physical loading across all movement planes covering ~3 km during match-play. (Madueno et al., 2017).

It is necessary to clarify the interaction between the physical, movement profiled, and technical variables of UF performance when considering the game context. In the quest for more realistic data, one aspect that has not yet been analyzed is whether the specific internal and external loads in UF and their limiting factors influence player performance. Match outcome (wins and losses) may also be different in relation to the internal and external loads, since the actions performed during the game aim to give the team as a whole the lead, with the current situation regarding whether the team is winning or losing possibly reflecting technical actions and consequently physical effort. In addition, there have been few studies elucidating the internal and external loads

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based on playing position (Raya-González et al., 2021). Thus, it is necessary that themed research consider this practical question in UF competition, since this information is important for decision-making during the training process. Based on the limitations of the extant research, the aim of the present study was to analyze internal and external loads according to the match performance outcome and the playing positions in competitive official UF matches.

Material & methods

Participants

The participants consisted of 56 UF players from 8 teams participating in an official Thailand UF Championship 2020 mixed-gender competition organized by the Flying Disc Association of Thailand (mean ± standard deviation: male (n=32), age: 24.6 ± 7.6 years, height: 175.1 ± 7.7 cm, body mass: 69.5 ± 17.4 kg, body mass index (BMI) 22.6 ± 5.5 kg·m^2, and body fat: 16.9±5.5%; and female (n=24), age: 22.9 ± 5.9 years, height: 164.5 ± 6.9 cm, body mass: 56.8 ± 6.8 kg, BMI 20.9 ± 3.1 kg·m^2, and body fat: 19.5±5.9%).

The players in each team consisted of 4 male and 3 female players. The data were collected during 4 matches involving competitive games (first round, quarter round, semi-final round, and final round.) The UF players were categorized according to their positional grouping, with the recruiting for this study covering all recognized UF positional groups: handlers (n=16), cutters (n=24), and deepers (n=16). After the match, the players were categorized based on performance outcome. Match outcomes were categorized into winners and losers. All participants were notified of the research procedures and the potential benefits and risks, and appropriate written informed consent was obtained from all participants. The study was approved by the Research Ethics Committee of Kasetsart University, Bangkok, Thailand in conformity with the Declaration of Helsinki (approval number KUREC HS64/002).

Design

The study was designed to analyze the internal and external loads during the official UF match (Thailand UF Championship 2020). The internal and external loads imposed upon UF players were collected during four official matches in a mixed-sex UF competition across 2 consecutive days. The playing pitch consisted of an outdoor, natural grass surface, spanning 100 m (including 2 x 18 m end zones) in length by 37 m in width. In tournaments, there is a default whether a game is won by 9 points, or it goes for a certain time within 50 minutes. The effective playing time during the study was 37–50 min. Data were recorded over temperature and humidity ranges of 30–35°C and 40–55%, respectively.

Procedure

A Polar Pro (Polar Electro, Kempele, Finland) device was used to determine each UF players' internal and external loads. Each participant wore identical Polar Team Pro straps (Polar Electro; Kempele, Finland) positioned on the center of the chest at the Xiphoid process level. The device (weight 39 g; dimensions 36 × 68 × 13 mm) was held in place on the lower sternum using an elastic band. Data were stored in the device and downloaded using the manufacturer's software (POLAR Team Pro, Software version 1.3.1; POLAR, Polar Electro Oy; Kempele, Finland). The heart rate (HR) was used to measure the internal loading during matches (excluding the breaks between periods). Continuous measurements of HR were obtained from all participants at 1 second intervals throughout game-play. Maximal (HRmax) and mean absolute HR (bpm) were determined. The mean relative HR (% HRmax) was also calculated: % HRmax = Exercise HR / [220 – age]) × 100

Each participant's mean relative HR was categorized into the proportion of playing time spent (%) working in pre-determined intensity zones. Five intensity zones were defined:< 75% (low), 75–80% (moderate), 81–85% (moderate-high), 86–90% (high), and >90% (very high) of individual HRmax. (Krustrup & Mohr, 2015). UF players' movements during the matches (external load) were recorded using a portable global positioning system (Polar electro; Kemple, Finland). A Polar Team Pro device was placed into a harness attached to specifically designed chest belts worn according to the manufacturer's instructions on the center of the chest at the level of the Xiphoid process (chest-mounted). All data were downloaded using the Team Pro web page (teampro.polar.com). During each match, the total distance (TD) was measured, with player activity divided into 5 speed zones: stationary or walking (0–3.9 km/h), jogging (4.0–7.9 km/h), quick running (8.0–13.9 km/h), high-intensity running (14.0–22.0 km/h), and sprinting (>22 km/h), according to Krustrup & Mohr (2015).

Ten minutes before each match, the chosen players were given an HR monitor, the vest, and the device. After fitting the equipment and once the initial and individual situational data of the players had been obtained, the exact starting time of the matches was noted. All matches were recorded to certify the data collected. After each game finished, the devices were removed. The matches were analyzed separately. Analyses were performed throughout the game, excluding the recovery time.

Statistical analysis

Data were presented as mean and standard deviation (SD) values. Mean values were compared for the internal load and external load variables. Before using parametric tests, the assumption of normality was verified using the Shapiro-Wilks W-test. Differences between the performance outcome (winners and losers) were compared using an independent t-test and one-way ANOVA was used to determine differences between playing positions, with Bonferroni Post Hoc tests used to identify specific differences. Statistical significance was tested at $P<0.05$.

Results

Table 1. Internal and external loads during official UF match for winners and losers.

Internal and external load variables	Performance outcome	
	Winners (n=28)	Losers (n=28)
HR (beat/min)	169.0 ± 8.4*	166.2 ± 7.7
HRmax (%)	86.2 ± 6.9*	83.3 ± 5.9
Distance covered (km)	2.6 ± 0.7*	2.3 ± 0.7
Number of sprints (n)	14.2 ± 4.5*	9.3 ± 3.3

* Significant difference (P<0.05) between winners and losers.

Data on the internal and external loads during official UF match-play between winners and losers (Table 1) showed that HR, % HR_{max}, distance covered, and number of sprints for whole matches for the winners group were higher (P<0.05) than for the losers (HR: 169.0 ± 8.4 vs 166.2 ± 7.7 beat/min, % HR_{max}: 86.2 ± 6.9 vs 83.3 ± 5.9% Distance covered: 2.6 ± 0.7 vs 2.3 ± 0.7 km, and number of sprints: 14.2 ± 4.5 vs 9.3 ± 3.3 time, respectively).

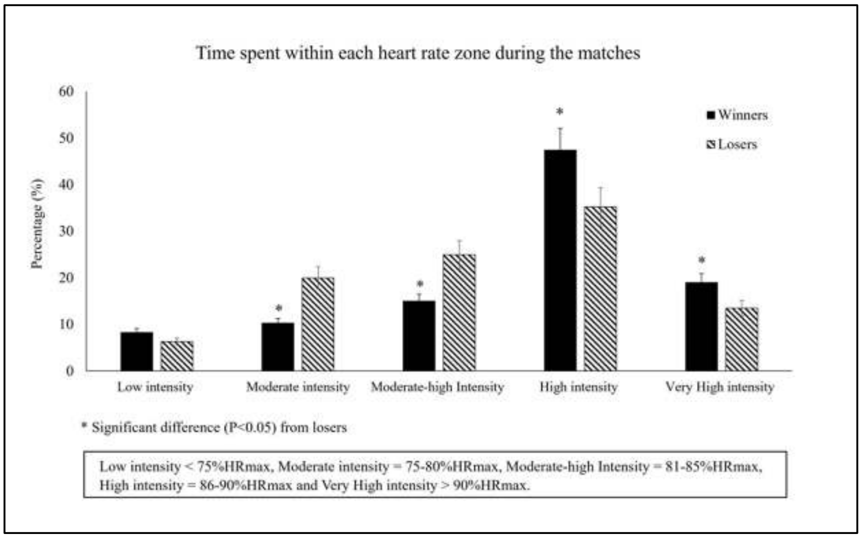

Figure1. Percentage of time spent by winners and losers in selected HR intensity zones during official UF matches played.

Figure 1 shows the percentages of time spent in selected HR intensity zones during the official UF matches played, indicating that the winners spent less time at the moderate intensity and moderate–high intensity (*P*<0.05) than the losers group (moderate intensity: 10.3 ± 3.1 vs 20.1 ± 5.4 % and moderate-high intensity: 15.0 ± 4.5 vs 25.0 ± 3.7) and spent more (*P*<0.05) time at the high intensity and very high intensity levels than the losers group (high intensity: 47.4 ± 13.3 vs 35.2 ± 14.7 % and very high intensity: 19.0 ± 6.8 vs 13.5 ± 5.9 %, respectively).

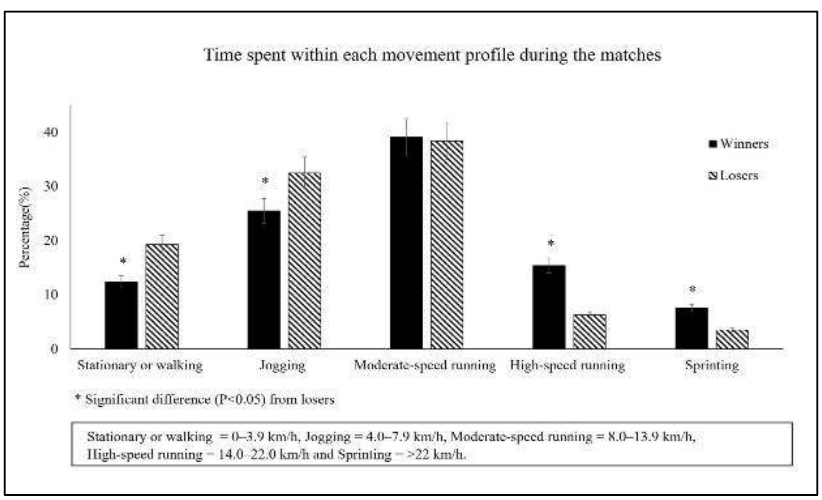

Figure 2. Percentage of time spent by winners and losers in different movement profiles of official UF matches.

The results for the time spent at different speeds (Figure 2) showed that the winners spent less (P<0.05) time stationary or walking, and jogging than the losers (stationary or walking: 12.4 ± 1.7 vs 19.3 ± 1.5 and jogging: 25.5 ± 1.6 vs 32.5 ± 1.9% respectively). In contrast, the times spent doing high-speed running and sprinting were higher (P<0.05) than for the losers (high-speed running: 15.4 ± 1.5 vs 6.3 ± 1.3% and sprinting: 7.6 ± 1.5 vs 3.5 ± 1.6%, respectively); however, there was no discernable difference between the times spent on moderate-speed running for the two performance outcome groups.

Table 2. Internal and external load during official UF matches based on playing position.

Internal and external load variable	Playing position		
	Handlers (n=16)	Cutters (n=24)	Deepers (n=16)
HR (beat/min)	167.8 ± 9.5	168.2 ± 10.8	169.0 ± 11.2
HRmax (%)	85.3 ± 5.5	84.3 ± 5.2	86.2 ± 5.3
Distance covered (km)	2.0 ± 0.7	2.2 ± 0.6	2.1 ± 0.7
Number of sprints (n)	3.1 ± 0.9	5.3 ± 0.5	10.2 ± 0.4*,#

Values are mean ± SD.

* Significant difference(P<0.05) between handlers. # Significant difference(P<0.05) between cutters.

The internal and external loads during official UF matches based on the playing positions (Table 2) showed that the number of sprints of the deepers was higher (P<0.05) than for the handler and cutter positions (deepers: 10.2 ± 0.4, handlers:3.1 ± 0.9, and cutters: 5.3 ± 0.5, respectively). There were no differences in any of the variables between the playing position groups (P>0.05).

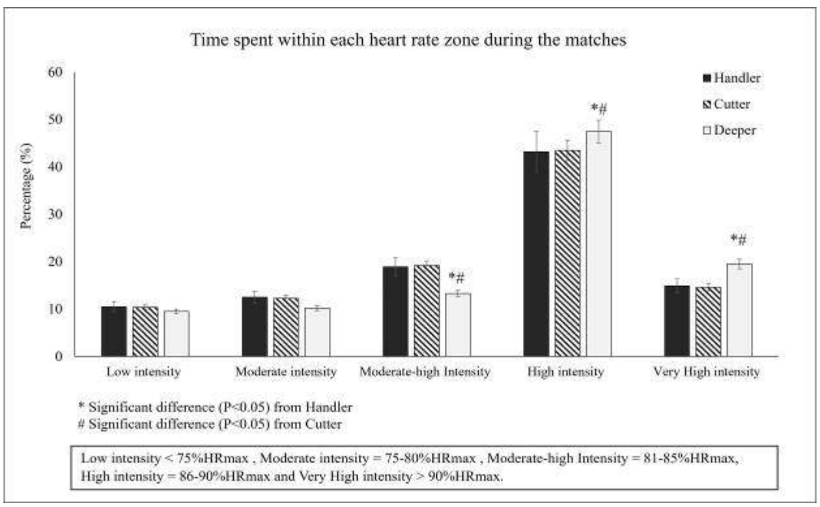

Figure3. Percentage of time spent by players in different positions in selected HR intensity zones during official UF matches.

Figure 3. shows the percentages of time spent in selected HR intensity zones during the official UF matches by playing position, with the deepers having less moderate-high intensity playing time (*P*<0.05) than the handlers and cutters (deepers: 13.3 ± 0.5, handlers: 18.9 ± 0.8 and cutters: 19.2 ± 0.6%, respectively), and more (*P*<0.05) high intensity and very high intensity time than the handlers and cutters (high speed running = deepers: 47.5 ± 13.7%, handlers: 43.2 ± 14.5% and cutters: 43.5 ± 14.9% and sprinting = deepers; 19.5 ± 4.7%, handlers: 14.9 ± 4.9% and cutters: 14.6 ± 5.2 %, respectively).

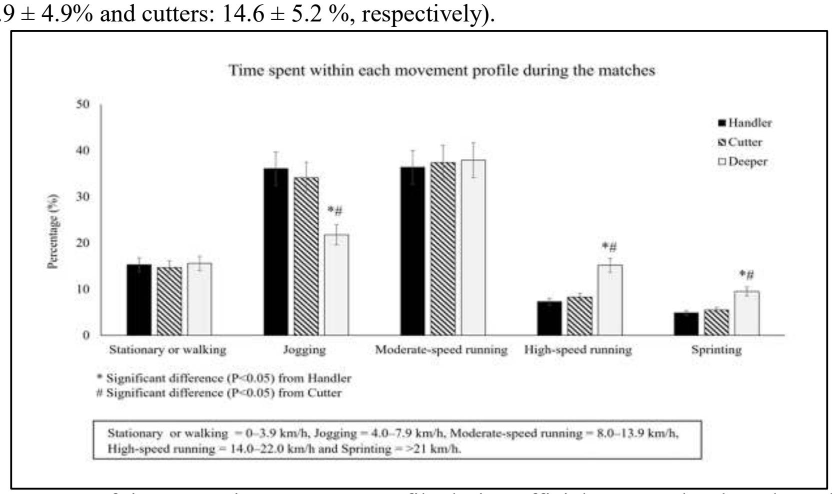

Figure4. Percentages of time spent in movement profile during official UF matches based on playing position.

Figure 4. shows the percentages of time spent in different speed categories during the Official UF match-played between playing position. The results show that the deepers position less moderate-speed running playing time ($P<0.05$) than the handlers and cutters position (deepers: 21.8 ± 1.5%, handlers: 36.1 ± 1.8 % and cutters: 34.1 ± 0.6 % respectively), In contrast, time spent high-speed running and sprinting were higher sprinting than the handlers and cutters position (high speed running = deepers; 15.2 ± 1.7%, handlers: 7.3 ± 1.5% and cutters: 8.3 ± 1.9 % and sprinting = deepers; 9.5 ± 1.7%, handlers: 4.9 ± 1.9% and cutters: 9.5 ±1.7%, respectively).

Discussion

The objective of this study was to compare the internal and external loads in mixed-sex UF players during official matches based on the match performance outcomes and playing positions. The main result of the study was that the internal and external loads differed between performance outcomes and playing position.

Comparison based on performance outcomes.

HR measurements were used to provide information about the aerobic energy turnover during match-play. Considering total time, the mean heart rate of the outfield players recorded in the present study showed that the winners had 169 beat/min, which corresponded to 86.2% of HR_{max} and was higher than that of the losers (166 beat/min or 83.3% of HR_{max}). Based on the results, the average maximal heart rate in the players in this study was similar to observations in other studies investigating UF players. For example, Krustrup & Mohr (2015)., Scanlan et al. (2015) and Madueno et al. (2017). Krustrup & Mohr (2015) reported on the HR responses experienced during competitive, male UF game-play. Players were observed to work on average at 82% HRmax, spending approximately 42% of playing time >90% HRmax. Scanlan et al.2015 examined the internal physiological responses associated with male and mixed-sex UF recreational game-play, with relative HR (male: 90% HRmax; mixed-sex: 94% HRmax) and Madueno et al. (2017) reported HR responses during the game for males at 88.3% HRmax and for females at 92% HRmax, which were slightly higher than what was found in the present study. The present results reflected an effect of match performance outcome on physiological responses. Specifically, the winning teams had a higher levels of percentage effort at high intensity(85–90% HRmax) and at very high intensity (>90% HRmax), while the moderate intensity (75–80% HRmax) and moderate-high intensity (80–85% HRmax) levels were higher in the losers. The proportion of playing time spent working in different HR intensity zones is displayed in Figure1. In the present study, the higher heart rate in the winners may have been a result of the higher load on their anaerobic metabolism than for the losers. This difference suggests a higher HR, which is consistent with the observation that winners group players were engaged more at the high-intensity (85–90% HRmax and very high-intensity (>90% HRmax) levels than the losers. In relative terms, the winners spent more time at the high intensity (47.4% of actual playing time) and very high intensity (19%) levels. These values indicated that for more than 66% of the time spent on the court, these players were performing very vigorous activity at high and very high intensity levels. For the losers, vigorous activity only accounted for 48% of their actual playing time. It is known that when teams want to win, they tend to increase their physical efforts to score, which increases physiological demand.

Analyses of the external load from movement activities can be used to quantify physical and movement patterns of team sports and so provide important guidelines for training in a specific sport. The results of the present study showed that the total distance covered and the number of sprints during whole matches were significantly different between performance outcome, with the average distances covered being 2.6 km and 2.3 km, and numbers of sprints being 14 and 9 for the winners and losers, respectively. The total distance covered observed in the present study was lower than that reported in other reported match research—4.7 km (Krustrup & Mohr, 2015), 3 km (Madueno et al., 2017), and 3.7–4.1 km (Raya-González et al., 2020). The results may be affected by many different parameters, including the participants who took part in the studies, the level of competition, the role of competition, and tactical disposition. The lower distance covered by the winners and losers in the present study was probably a result of the role of competition.Furthermore, there was a significant difference in the time spent at high intensity (high-speed running and sprinting) levels between the winners and losers, which indicated that the winners used more frequent high-intensity effort during a game.

Notably, in each activity during the game, the losers group spent more time in the stationary or walking and jogging categories than the winners group, which suggested that they spent less time in high-speed running and sprinting than the winners group. In basketball, the difference between winning and losing teams is usually related to high-intensity actions, with a magnitude of the differences classified as moderate or large (Fox et al.,2019). In another study of male soccer players, Mohr et al. (2003) reported that the ability to perform high-intensity exercise was an important predictor of success in soccer, with elite players able to perform more high-intensity running than their less skilled counterparts. Winning teams performed more high-intensity actions such as accelerations, decelerations, jumps, and change of direction. Lago et al. (2009) suggested at the elite level team members who are winning the match tend to increase their work-rate. Alternatively, although teams who are losing the match may decrease their work rate during a specified period (Paul et al., 2015, Castellano et al., 2011), they may quickly lose the motivation to keep the elevated work rate, which may be especially evident as the score difference increases negatively (through conceding more goals) (Redwood-Brown et al., 2018). Some reasons that could explain these differences can be related to the score. Having a positive difference in points could provoke that the players to perform more high-intensity actions to balance the score. Gómez Carmona et al. (2019) reported that the total distance covered and the time spent at high intensity were greater when the score was unbalanced.

Likewise, the tactics used by teams can affect physical activities, mainly the distances traveled at high speed (Sampaio et al., 2014). Teams often apply different defensive or offensive tactics. The defensive style (man-to-man or zone-based) will vary the player's physical activities on the field. When a team lost and had selected a zone-based defense, it registered fewer high decelerations and jumps. Lago et al. (2010) reported that elite soccer players engaged in more high-intensity activity when winning than when losing. Accordingly, players may engage in less low-intensity activity when losing than when winning, in an attempt to recover from an unfavorable position. Furthermore, when a team is winning, its players most often prefer to counter-attack and thus play on the basis of limited pressing, with their own goal area better secured. In this situation, a winning team must return quickly to the original formation after each offensive action, with this affecting the distance covered by players at low intensity. This information indicates a need for increased low-intensity mobility of players.

Comparison based on playing position.

There were no significant differences between the positions in the internal load (HR and % HRmax) during the UF matches. The absolute and relative HR responses during the UF match-play were significantly different according to the 3 playing positions of handlers, cutters, and deepers (167, 168, and 169 bpm respectively). These values corresponded to relative responses as a percentage of maximum HR (% HRmax) of 85.3, 84.3, and 86.2% HRmax, repsectivley, during live playing time.

There were significant differences between the three positional groups for time spent in selected HR intensity zones during official UF match play at the moderate-high intensity, high intensity, and very high intensity levels, with the exception being times spent at the moderate-high intensity and low intensity levels (Figure 3). The deepers position involved less moderate-high intensity playing time ($P<0.05$) than the handlers and cutters (13.3%, 18.9%, and 19.2%, respectively), and deepers spent more ($P<0.05$) time at the high intensity and very high intensity levels than the handlers and cutters (high intensity: 47.5%, 43.2%, and 43.5%, respectively, and very high intensity: 19.5% 14.9%, and 14.6%, respectively). In the present study, the higher heart rate in the deeper position may have been a result of those players having the highest amounts of high speed running and sprinting movements, which were significantly more than for the other two positions, while the deepers were also engaged in significantly less time jogging than the handlers and cutters (Figure 4). This was supported by Parinella,& Zaslow (2004), who reported that the deeper position may also require the physically strongest players as they had to have the most physical contact at high intensity and also had higher levels of stopping at high intensity as well as swerving and slowing more rapidly. These activities stimulate the heart rate and intensity during the match.

In the present study, there were significant external load differences between the handlers, cutters, and deepers in the number of sprints during matches. (3.1± 0.9, 5.3± 0.9 and 10.2±0.4, respectively.) The deepers performed more sprints than the other positional groups. These findings were in agreement with those of Parinella and Zaslow (2004), who reported that Ultimate players needed to be able to move rapidly from one spot to another, in particular, the deeper, who have the primary purpose of creating playing points with speed also helping the deepers to keep up with a play offensive. In addition to speed, players require the ability to perform quick changes in direction and react to the movements of the opponents. Hence, agility is crucial to performance in Ultimate players, especially those playing in the deeper position. Another essential part of Ultimate is lower limb explosive power. Due to the aerial flight of the disc, players often have to jump or dive to catch or intercept the disc. Lower limb explosive power and jumping have also been linked to sprint speed; hence power is essential to optimize Ultimate performance.

Figure 4 illustrates there were significant differences between positions in the percentage of time spent in each speed category. For example, deepers spent significantly more time ($p < 0.05$) involved in high-speed running (14–21 km/h) and sprinting(>21km/h) than any other playing position.

However, the total distance covered by deepers was not significantly different from handlers and cutters (Table 2). Even though handlers, cutters and deepers typically practise at different intensities, the results showed that the external load demand for all the UF players was the same for all positions as there were no significant differences between the distances covered based on playing position. Hence, the three positions could be considered to be physiologically identical. This is uncharacteristic of sports, such as basketball, field hockey, and soccer, with positional differences, where the total distance travelled did vary between players in different positions (Di Salvo et al., 2007; Jennings, Cormack, Coutts, & Aughey, 2012).

Conclusions

There were significant differences between some internal and external load variables during competitive matches based on the match outcomes and playing positions. The winning teams invested a higher percentage of effort at high intensity (85–90% HRmax and very high intensity (>90% HRmax) levels than the losing teams and also spent more time doing high-speed running and sprinting than the losers group. Based on the playing positions, the deepers spent more time doing high-speed running and sprinting than any other playing position.

The data presented here could be considered norms for elite UF players and provide a benchmark for future comparisons, as well as representing a scientific basis for developing position-specific conditioning/training protocols in UF.

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

Bradley, P. S., Di Mascio, M., Peart, D., Olsen, P., & Sheldon, B. (2010). High-intensity activity profiles of elite soccer players at different performance levels. The journal of strength & conditioning research, 24(9), 2343-2351.

Castillo, D., Raya-González, J., Clemente, F., Conte, D., & Rodríguez-Fernández, A. (2021). The effects of defensive style and final game outcome on the external training load of professional basketball players. Biology of sport, 38(3), 483-490.

Castellano J, Blanco-Villasenor A., & Alvarez D. (2011). Contextual variables and time-motion analysis in soccer. International Journal of Sports and Medicine, 32(6), 415–21.

Castillo, D., Raya-González, J., Scanlan, A.T., Domínguez-Díez, M., &Madueno, M.C.(2020). Influence of opponent ranking on the physical demands encountered during UF match-play. Sports Biomechanics, 22(7),822-833.

Choi, D.-H.; Kim, S.-M.; Lee, J.-W.; Suh, S.-H., & So, W.-Y. (2015). Winning factors: How players' positional offensive and defensive skills affect probability of victory in the Korea basketball league. International Journal of Sports Science and Coaching, 10(2-3), 453-459.

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F. J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. International Journal of Sports Medicine, 28(3), 222–227.

Fox, J. L., Stanton, R., Sargent, C., O'Grady, C., & Scanlan, A. T. (2019). The impact of contextual factors on game demands in starting, semiprofessional, male basketball players. International Journal of Sports Physiology and Performance, 15(4), 450-456.

González, J. R., Scanlan, A. T., Díaz, S. S., & Alvira, D. C. (2020). Sex-based differences in the external loads imposed during an official Ultimate-Frisbee competition: A Pilot Study. European Journal of Human Movement, (45),2.

Jennings, D., Cormack, S. J., Coutts, A. J., & Aughey, R. J. (2012). GPS analysis of an international field hockey tournament. International Journal of Sports Physiology and Performance, 7(3), 224–31.

Krustrup, P., & Mohr, M. (2015). Physical demands in competitive UF. Journal of Strength and Conditioning Research, 29, 3386–3391.

Lago-Peñas, C. (2012). The role of situational variables in analysing physical performance in soccer. Journal of Human Kinetics, 35, 89–95.

Lago C, Casais L., Dominguez E., & Sampaio J. (2010). The effects of situational variables on distance covered at various speeds in elite soccer. European Journal of Sport Science. 10(2),103-109.

Lorenzo, A., Gómez, M. Á., Ortega, E., Ibáñez, S. J., & Sampaio, J. (2010). Game related statistics which discriminate between winning and losing under-16 male basketball games. Journal of sports science & medicine, 9(4), 664-668.

Madueno, M. C.; Kean, C. O., & Scanlan, A. T. (2017). The sex-specific internal and external demands imposed on players during UF game-play. The Journal of Sports Medicine and Physical Fitness, 57(11), 1407–1414.

Mohr, M, Krustrup, P, and Bangsbo, J.(2003). Match performance of high-standard soccer players with special reference to development of fatigue. Journal of Sports Science. 21,519–528.

Parinella, J., and E Zaslow (2004). Ultimate techniques & tactics.Human Kinetics Publishers.

Paul DJ, Bradley PS, Nassis GP. (2015) Factors affecting match running performance of elite soccer players: shedding some light on the complexity. International Journal of Sports Physiology and Performance. 10, 516-519.

Raya-González, J., Castillo, D., Rodríguez-Fernández, A., & Scanlan, A. T. (2021). External match loads imposed upon Ultimate Frisbee players: A comparison between playing positions. Science & Sports, 36(2), 160-162.

Scanlan, A. T., Kean, C. O., Humphries, B. J., & Dalbo, V. J. (2015). Physiological and fatigue responses associated with male and mixed-gender UF game play. Journal of Strength and Conditioning Research, 29, 2600– 2607.