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Comparison of physical match demands for female Danish national team players across playing position and how these change from youth to adult

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Contents

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Abstract

Aim*:** The aim of the present investigation is to identify differences in position-specific match demands for female football players across age groups (U17, U19 and senior national team) and playing positions through analyses of match performance data from female Danish national team players collected from the Danish FA test and tracking database. ***Method: Data from all competitive matches between January 2020 and March 2023 was collected. The players were categorized by age (U17, U19 and A-team) and playing position: central back (CB), full back (FB), central midfielder (CM), wide midfielder (WM) and forward (FW). Data from players playing at least 75 minutes of a match was included in the following statistical analysis. A total of 250 observations were included. Metrics included for statistical analysis: distance covered per minute, top speed, accelerations per minute, decelerations per minute, number of sprints per minute, distance covered in speed zones (15+, 18+ and 25+ kph) per minute. A one way ANOVA was performed for each metric in order to identify differences in physical match performance across playing positions and age groups. ***Results*:** The present study found an increase in the number of accelerations and decelerations per minute from U17 to U19 and senior. Attacking oriented playing positions (FW and WM) performed more H_{dec} than the central and defensive oriented positions (CB and CM) at the U17 and A-team. Similar findings appeared with regard to distance covered at the speed zones 15+, 18+ and 25+ kph with FW and WM covered a greater distance than CB and CM per minute, though at 25+ kph only WM covered a greater distance than CB and CM. ***Conclusion*:** This study was able to identify a general increase in physical demands during international competitive matches from U17 to U19 and senior level. The biggest increase happened in the transition from U17 to U19 and not from U19 to senior level. Especially the demands of performing accelerations and decelerations differed from U17 to U19 and the A-team. Wide and attacking oriented positions (WM and FW) should be able to run a greater distance at high speed during a match compared to defensive and central players (CB and CM) when playing in the A-team.

***Index Terms*—Soccer - Female soccer - Work demands - GPS monitoring - Sprinting - Accelerations and Decelerations - High intensity**

I. Introduction

Women's football is a growing sport. The average live match audience at the Women's World Cup in 2019 was 17.27 million which is a 106% increase since 2015[1]. As a results of the increasing competition a certain physical capacity is needed in speed, endurance and agility in order to compete at the highest level. Furthermore, the game requires repeated efforts in high intensity activities including high intensity running and change of direction[2][3]. Match analysis in football have therefore experienced increasing development in recent decades. This may be due to the fact that such analyses can help to identify specific demands of individuals and teams[4]. Knowing these demands on top-level football gives coaches an opportunity to develop position-specific training protocols for players and optimize physical capacity[5]. Performance based studies has in recent years increased in women football which has decreased the gap between research in male and female football[6][7][8]. Studies have investigated the comparison of position specific demands of female players at different league levels and international level[9][10][11][12][13]. During the 2019 World Cup, the outfield players ran a distance of 9 to 11 km with central midfielders running the greatest distance on average while the wide midfielders covered the greatest distance at a speed above 23 kph[13]. Furthermore, studies have also compared physical demands at international matches with domestic league matches[14][15]. Likewise, it has been concluded that players perform better at international matches than when participating in domestic league matches[14]. However, comparison of different match demands between adult national players and youth national players at international level is still a gap in the current literature[16]. It would therefore be interesting to investigate if the relative position-specific physical match demands are the same across age groups. National team players were found to achieve better scores in physical tests when compared with sub elite athletes, which demonstrate the importance of the physical characteristics[17].

Many studies have focused on physical capacity through testing of football players across age groups[18][19][20][21]. The studies found physical capacity to increase from youth to adult level but did not distinguish between playing positions. Datson et al[22] found high intensity endurance to be a prognostic value in identifying young players that

have reached or had potential to the elite level of female football. Currently, the Danish FA (DBU) expects the youth national team players to be able to run a certain distance when performing the Yo-Yo intermittent recovery test Level 1 (YYIR1). However, it is questionable if all the players should be able to run the same distance if the match demands differ between position.

Previous studies have identified different match demands across age groups while other have examined the difference between playing positions. Mara et al[2] found central defenders to cover the shortest total distance, high speed running distance and sprinting distance while wide defenders, wide attackers and central attackers covered the greatest sprint distance. The greatest total distance and distance at high speed running was covered by wide attackers, midfielders and wide defenders. Similar results were found by Panduro et al[23] who investigated match demands of the players from the best Danish women's football league. Central defenders covered a significantly shorter total distance than full backs, central midfielders and wide midfielders while all outfield positions covered a significantly greater distance at high speed and very high speed running compared to central defenders. No significantly differences were found on high accelerations between positions but all outfield positions performed a significantly greater amount of high decelerations compared to the central defenders. Kobal et al[24] compared the match activity in Brazilian elite female footballers at the age groups senior, U20 and U17. They found senior players to cover a greater sprint distance and perform more accelerations and decelerations per minute than U17 and U20. Also, no differences were found between U17 and U20. To the authors' knowledge only one study have examined the differences in physical match demands of national team players at different positions during international competitions in youth to adult. Ramos et al[16] managed to find several differences between each position across ages in high intensity running, total distance, accelerations and decelerations. Senior players experienced greater demands in several positions than U17 and U20 players. U20 players were found to experience greater physical demands in four out of five positions compared to U17 players. It is questionable if the results from the above studies will look similar in another context like the Danish national teams. A study investigating differences in physical match demands for Danish national team players has not yet been conducted.

The aim of the present investigation is to identify differences in position-specific match demands for female football players across age groups (U17, U19 and senior national team) and playing positions through analyses of match performance data from female Danish national team players collected from the Danish FA test and tracking database.

The complexity of the present study complicates the making of a concisely and specific hypothesis. Because of this, a more generalized hypothesis has been suggested. Based on the current literature, the physical match demands are expected to increase from youth to adult. Additionally, the demands are expected to differ between playing positions.

II. Methods

An overview of all competitive matches played by the Danish U17, U19 and adult national team between the January 2020 and the March 2023 was created using "Landsholdsdatabasen"[25].
Data from the national team matches were collected from Polar Team Pro. For each match, four to five players were selected in Polar Team Pro and their GPS-position as well as their current velocity was used to estimate the beginning and end of each half. After the start and end of each half was determined, the following data was exported from Polar Team Pro: Player number and name, half duration, total distance, top speed, number of sprints, distance run at different velocities, number of low, moderate and high accelerations and decelerations. Playing position was defined by the line-ups found on UEFA's website[26]. Starters and substitutes were identified using "Landsholdsdatabasen" and UEFA's website. Positions were defined as center back (CB), full back (FB), central midfield (CM), wide midfield (WM) and forward (FW).

The players were allocated to one of the five predefined categories of positions by the authors of the study using the same method as Di Salvo et al[5]. When doubt occurred about the playing position, heat maps from the match were used to allocate the players to the correct playing position. Each team used the same formation of line-up in each of the chosen games. The formation used differed between the youths and adult team. U17 played 4-3-3, U19 played 4-3-3 and the A-team played 3-4-3. Playing time was defined by half duration and the time the substitution was made. Data from players playing at least 75 minutes of the match was collected for further analysis. Incomplete data was deleted. This included GPS-data from halfs where the player did not participate in the match. If a GPS did not collect data the entire time while the player was on the pitch, the player was excluded from the analysis.

A. Data processing

Data from different velocities were divided into distance covered at 15+, 18+ and 25+ kph. Number of accelerations and decelerations were allocated in 3 different categories: 0.50-1.49m/s^2, 1.50-2.99m/s^2 and 3.00-50.00m/s^2. To compare players playing full time with players being

Profile	Variable	Definition
Acceleration	L_{acc}	Total number of low-intensity accelerations per minute (0.50 - 1.49 m/s²)
	M_{acc}	Total number of moderate-intensity accelerations per minute (1.50 - 2.99 m/s²)
	H_{acc}	Total number of high-intensity accelerations per minute (3.00 - 50.00 m/s²)
Decelerations	L_{dec}	Total number of low-intensity decelerations per minute (0.50 - 1.49 m/s²)
	M_{dec}	Total number of moderate-intensity decelerations per minute (1.50 - 2.99 m/s²)
	H_{dec}	Total number of high-intensity decelerations per minute (3.00 - 50.00 m/s²)
Running	TD	Total distance per minute covered
	$15 + kph$	Total distance per minute covered by running (above 15 kph)
	$18 + kph$	Total distance per minute covered by running (above 18 kph)
	$25 + kph$	Total distance per minute covered by running (above 25 kph)
	TS	Maximum speed reached (kph)
	SPM	Sprints per minute (Velocities above 19.8 kph were defined as a sprint)

Table I
Metrics included for analysis

substituted after 75 minutes, all data except top speed was divided with the numbers of minutes spend on the pitch during the match by the player. To create an overview of potential differences between playing positions, radar charts were created based on z-scores from each position (Appendix: Figure 13-24).

B. Statistical analysis

A total of 250 observations from the matches at U17 (n=12), U19 (n=9) and the A-team (n=16) were included in the statistical analysis (Table II). All statistical tests

	CB	CM	FB	FW	WM
U17	13	24	19	16	16
U19	20	15	14	5	11
A-team	40	23	0	19	15

Table II

Sample (n) of observations categorized by age group and playing position. Under-17 players (U17), under-19 players (U19), adult national team (A-team).
Central back (CB), central midfield (CM), full back (FB), forward (FW), wide midfield (WM).

were performed using SPSS Statistics version 28 (SPSS inc, Chicago, IL). Shapiro Wilk test of normality was utilized to check for normal distribution of the data. In cases of violation of normality, the following statistical parametric tests were run regardless well knowing that the violation could have an effect on the statistical power[27]. Box plots were used to identify outliers. Several outliers were found, but only two outliers were excluded due to very unrealistic values. These values were top speed values of 54.4 and 49.4 kph. All other outliers were kept in the analysis as they consisted of realistic values. Homogeneity of variances was assessed by "Levene's test of homogeneity of variances". In cases of unequal variances, a Welch ANOVA was used to identify differences between groups. Metrics included for analysis are represented in Table I.

1) Physical demands across age groups independent of playing position:

A one-way ANOVA was performed for each metric to determine if the physical demands during competitive international football matches differed between age groups independent of the playing position. Observations were divided into U17 (n=88), U19 (n=65) and A-team (n=97).

2) Comparison of each position between age groups:

All observations were divided into playing position for further analysis. A one-way ANOVA was performed for each metric to determine if the physical demands during international football matches differed between the same playing position across age groups. An independent-samples t-test was used for FB as the position only was played at U17 and U19.

3) Comparison of playing positions within the same team:

All observations were divided into age groups for further analysis. A one-way ANOVA was performed for each metric to determine if the physical demands during international football matches differed between playing positions within the same team.

III. Results

In this section, only selected results will be presented. All data are mean ± standard deviation unless otherwise stated. The results are chosen based on their relevance for understanding the difference in physical match demands between age groups and playing positions. An overview of the results is presented in table III. The results have been illustrated in the form of bar charts as well and are available for review in the appendix.

		CB	CM	FB	FW	WM
TD	U17		a	b	a	a
	U19		a	a,†		
	A-team	†	a		b,‡	a,d
$15 + kph$	U17					a
	U19			†		
	A-team					a,b,d
$18 + kph$	U17					a,b
	U19					
	A-team				a	a,b,d
$25 + kph$	U17			b	b	b
	U19					
	A-team					a,b,‡
TS	U17			b		b
	U19					
	A-team					
SPM	U17				a,b	b
	U19			†		
	A-team				a,b	a,b,d,†
L_{acc}	U17					
	U19	†	†	†	†	†
	A-team	†	†	†	†	†
M_{acc}	U17					
	U19	†		†	†	†
	A-team	†	†		†	†
H_{acc}	U17					
	U19	†		†		
	A-team	†	†		†	†
L_{dec}	U17					
	U19	†	†		†	†
	A-team	† ‡	†		†	†
M_{dec}	U17		a			
	U19	†	†	†	†	†
	A-team	†			†	†
H_{dec}	U17				a,b	a,b
	U19			a,†		
	A-team		†		a,b	a,b,†

Table III

Significant differences found on the metrics between the playing positions as well as age groups.
Total distance per minute (TD), distance covered above 15 kph (15+ kph), 18 kph (18+ kph) and 25 kph per minute (25+ kph), top speed (TS), sprints per minute (SPM), number of low (L_{acc}), moderate (M_{acc}) and high (H_{acc}) accelerations per minute, number of low (L_{dec}), moderate (M_{dec}) and high (H_{dec}) decelerations per minute
Under-17 players (U17), under-19 players (U19), adult national team (A-team)
Central back (CB), central midfield (CM), full back (FB), forward (FW), wide midfield (WM)
(a)significant different from CB
(b)significant different from CM
(c)signifikant different from FB
(d)signifikant different from FW
†significant different from U17
‡significant different from U19

A. Physical demands across age groups

It it noticeable that the U19 players covered the greatest distance 15 kph+ ($p<.05$) compared to U17 and the A-team. On average, the A-team players had a higher TS during the matches than U17 ($p<.05$). U19 performed more SPM compared to U17 ($p<.05$). The number of L_{dec}, M_{dec} and H_{dec} did not differ between U19 and the A-team, though the U17 performed significantly less L_{dec}, M_{dec} and H_{dec} compared to U19 and the A-team ($p<.05$). The exact same pattern was found in the number of L_{acc}, M_{acc} and H_{acc} ($p<.05$).

B. Differences between playing positions within the same team

In the U17 team, CB was found to cover a shorter TD during matches than CM, FW and WM ($p<.05$). Furthermore, CM covered a greater TD than FB ($p<.05$). Additionally, CB in the U19 team was found to cover a shorter TD than CM and FB as well ($p<.05$). A similar pattern was found for the A-team, where CB and FW covered a shorter TD than CM and WM ($p<.05$) (Figure 1). In the U17 team, a difference of the distance covered at 15+ kph was only found between WM and CB, while in the A-team, WM covered a greater distance at 15+ kph than CB, CM and FW ($p<.05$) as well (Figure 2).
WM covered a greater distance at 18+ kph than CB and CM at U17 ($p<.05$). At the A-team, WM covered a greater distance at 18+ kph than CB, CM and FW ($p<.05$). Additionally, FW covered a greater distance at 18+ kph than CB as well ($p<.05$) (Figure 3).
Furthermore, at U17 CM covered a shorter distance at 25+ kph than FB, FW and WM ($p<.05$), while WM covered a greater distance at 25+ kph than CB and CM at the A-team ($p<.05$) (Figure 4).

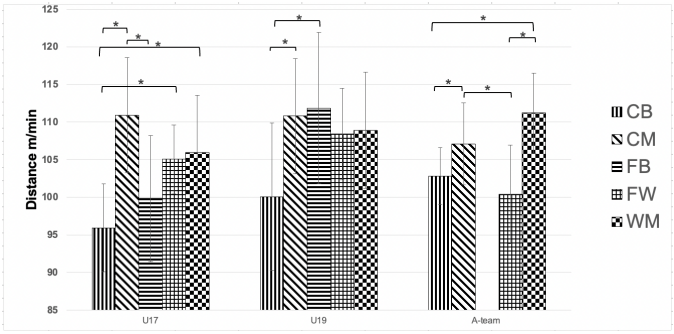

Figure 1. *Mean distance covered per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

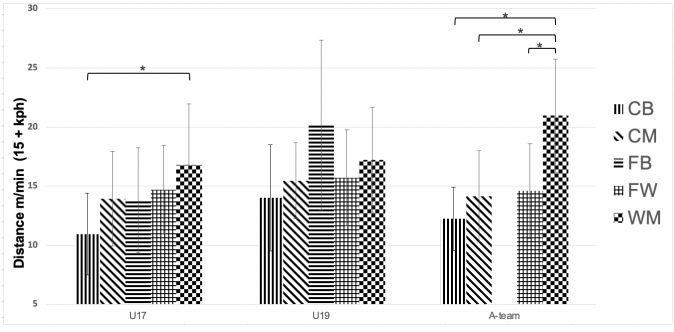

Figure 2. *Mean distance covered per minute at a speed above 15 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

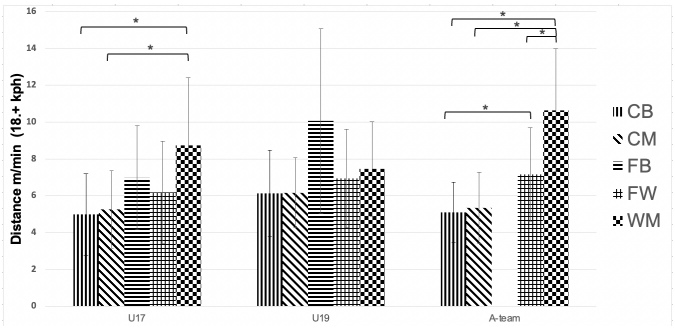

Figure 3. *Mean distance covered per minute at a speed above 18 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

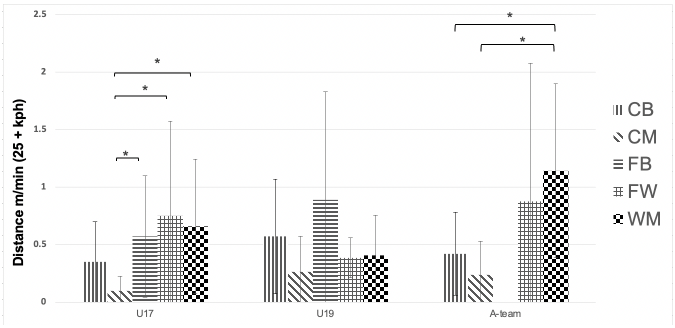

Figure 4. *Mean distance covered per minute at a speed above 25 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

A greater amount of H_{acc} was performed by FW compared to CB and CM in the A-team (p<.05) (Figure 5). Lastly, regarding the H_{dec}, WM and FW performed significantly more than CB and CM in the U17 and the A-team (p<.05) (Figure 6).

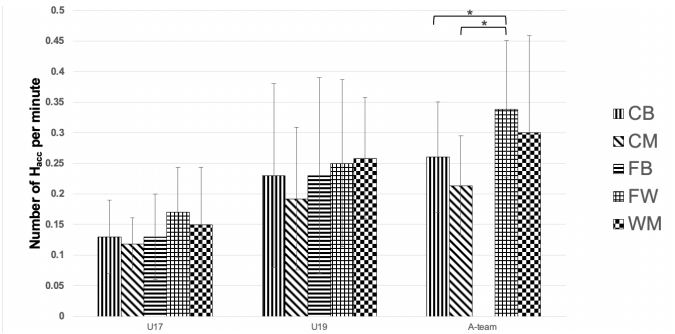

Figure 5. *Mean number of high accelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

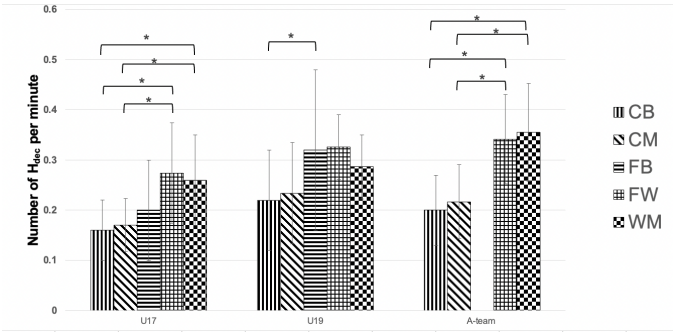

Figure 6. *Mean number of high decelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

C. Comparison of each position across age groups

The amount of L_{acc} was found to increase from U17 to U19 and the A-team for all positions (p<.05) (Figure 7). Furthermore, U17 performed less M_{acc} than U19 and the A-team at the CB, FB, FW and WM (p<.05). Though, the CM at U17 only performed less M_{acc} than the CM at the A-team (p<.05) (Figure 8). At the CB and FB position, a smaller number of H_{acc} was performed by U17 compared to U19 (p<.05) (Figure 9).

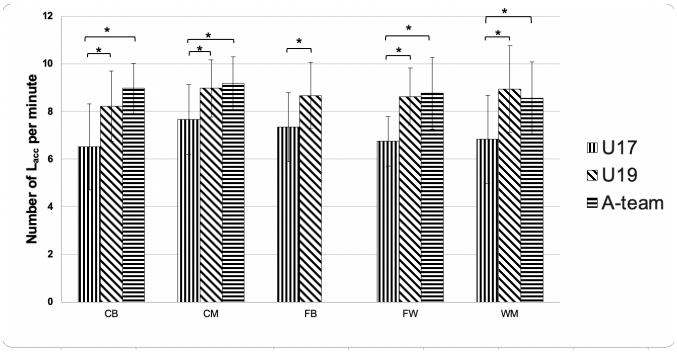

Figure 7. *Mean number of low accelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

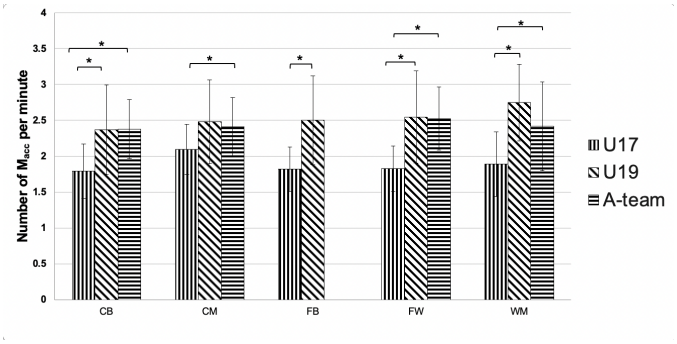

Figure 8. *Mean number of moderate accelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

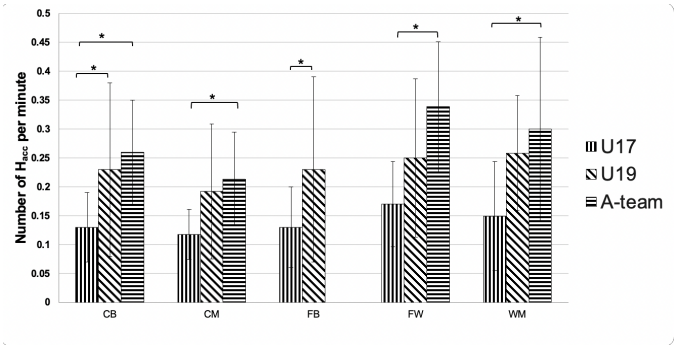

Figure 9. *Mean number of high accelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

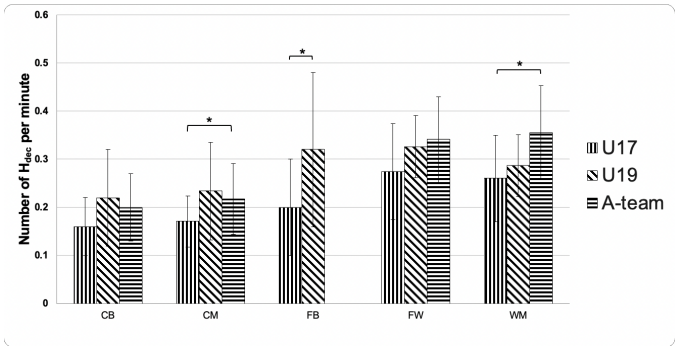

Figure 12. *Mean number of high decelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

Less L_{dec} were performed by U17 compared to U19 and the A-team at CB, CM, FW and WM (p<.05). Furthermore, CB at U19 performed significantly less L_{dec} than the CB at the A-team as well (p<.05) (Figure 10). A very similar pattern was found regarding M_{dec} with U17 performing a smaller amount than U19 across all playing positions, while only performing less than the A-team at CB, FW and WM (p<.05) (Figure 11). With regard to H_{dec} U17 performed a smaller number than U19 at FB and less than the A-team at CM and WM (p<.05) (Figure 12).

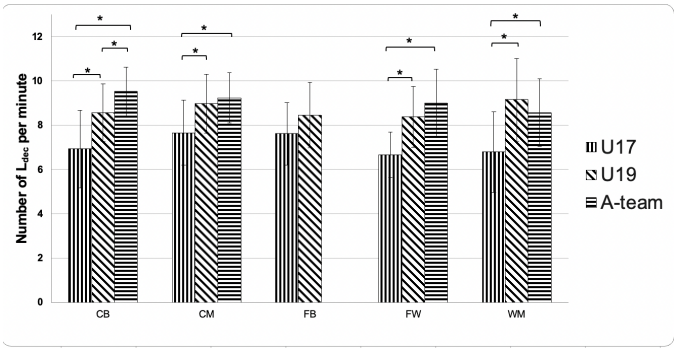

Figure 10. *Mean number of low decelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

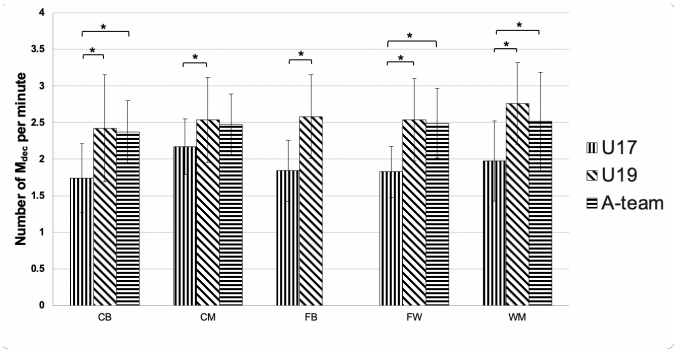

Figure 11. *Mean number of moderate decelerations per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

IV. Discussion

It has been suggested that when dividing outfield positions, the best method to distinguish between playing positions is to divide them into five positional groups: CB, FB, CM, WM and FW[5]. Studies have often used a more generalized assessments and only divided playing positions into defenders, midfielders and forwards. A study by Bradley et al[11] is one of the first studies to investigate physical match performance for female football players and to divide the players into five playing positions. Their sample consisted of only 59 observations. However this study primarily aimed to compare the difference between male and female match demands. Furthermore, a limited number of studies has investigated female players at difference playing positions at international level. Most studies has included players competing in the highest division of the national league[28][29][11][4]. Especially in the Scandinavian countries, there is a lack of research on female football players competing at international level. The present study is the first to examine the different demands placed on youth national teams and the A-team in Denmark. The most comparable study concerning Danish female players is a study by Larsen et al[30], who examined position-specific demands in the best Danish womens' league.

A. Differences between playing positions within the same team

Across all age groups, CM covered a greater distance per minute than CB. This pattern may indicate that CM players are actively involved in both offensive and defensive actions of the match. Additionally, in each age group CB is the position that emerged to generally cover relatively short distance per minute, which may indicate that this defensive oriented position involves less running than attacking oriented positions. The present findings support previous research which highlights that midfielders cover a greater total distance than defenders during international female matches[3][31][14]. Likewise, a report from FIFA showed that on average CBs covered the lowest and CMs the largest total distance compared

to the other outfield players during all regular-time matches of the FIFA Women's World Cup Canada 2015 and Germany 2011[7]. This observation may indicate the importance of identifying players with great endurance for the CM position and also increase focus on working with the optimization of endurance for players who play CM. The difference in endurance between different positions has also been demonstrated through physical tests such as the Yo-Yo intermittent recovery test[32]. A study by Mohr et al[10] found that CB performed worse in the Yo-Yo intermittent recovery test performance than CM and FB.

Another interesting finding in the present study was the distance covered in the different speed zones. At the A-team WM covered the greatest distance at 15+ kph and 18+ kph. Likewise at 25+ kph did WM cover a greater distance per minute than CB and CM. This demand for WM at adult level competition might be a result of the Danish A-team not playing with FBs like the U19. The WMs at U17 covered a greater distance per minute than CB at speed zones 15+ kph and 18+ kph. Furthermore did U17 WM cover a greater distance per minute than CM at 18+ and 25+ kph. Previous studies has examined high intensity running in female football. Bradley et al[33] examined high intensity running during elite football matches of the English FA Premier League, and found WM to be the position which covered the greatest distance and found CB to cover the shortest distance. Additionally, other studies have found that CM and CB covered a similar distance while sprinting[7][6]. These differences in sprinting demands between WM and the two central playing position (CB and CM) is likely related to positional requirements in match-play. According to Di Salvo et al[34], CM players tend to engage in a higher amount of short and explosive sprints, which has been explained by the limited space and congestion in the central areas of the pitch compared with the wider areas. Furthermore, it has been suggested that attacking oriented positions like WM and FW has to complete longer sprints because of the need to make fast movements from defenders to gain opportunities to score[34]. Findings in the present study can highlight the importance of why it is necessary to understand physical demands of central and wide positions. Additionally, it can help understand the match demands and the impact it can have on training regimes of sprint performance.

Maximum acceleration and deceleration are considered as a "highly intensive" running metric, due to the high metabolic and mechanical stress it causes[35][36][37]. Especially the metabolic cost at maximum acceleration and deceleration is higher than other metrics like running at constant velocity and sprinting[36][37] and especially deceleration has the ability to be a critical mediator of load-related injuries[37]. Only a limited number of studies have previously examined accelerations and decelerations in detail in elite female football. Additionally, the existing studies concerning this topic have encountered limitations in terms of sample size. Likewise, the categorization of positions is also generalized to three positions[15] instead of five as in the present study. Furthermore, the thresholds for accelerations and decelerations varies between studies which makes it difficult to compare[38]. The current study did find U17's and the A-team's FWs and WMs to have a significantly greater amounts of high decelerations per minute compared to CM and CB. Furthermore, FBs were found to perform a greater amount of high decelerations than CB at U19. These findings has been reported in male matches as well. Oliva-Lozano et al[39] also reported WM to perform a greater amount of high deceleration than CB. They suggest that players playing in the wide area of the pitch combined with an offensive role increase the probability for high sprint demands more than playing central and defensive positions. This is supported by the present study where FW performed a greater amount of H_{acc} compared to CB at the A-team. In expansion of this, positions with a more offensive role is most likely to perform change of directions to create scoring opportunities[34] and therefore requires frequent decelerations and accelerations[15]. This is also supported by Ramos et al[16] who found that the amount of accelerations and deceleration were linked to high intensity running distance during match play[16]. The present findings may indicate that positions at the wide areas of the pitch should focus on including incrementally progressive exposure to deceleration and acceleration loadings in training as it may indicate that they are more predisposed to powerful decelerations and accelerations and thus a greater workload, which may increase the risk of overload[37].

B. Comparison of each position across age groups

Primarily, existing literature comparing physical match performance in female football has focused on comparing female players playing in international games with domestic league games[14][15]. Other studies have compared female players playing at different league levels from top league to lower ranked leagues[9][10]. Larsen et al[30] found differences in running performance between positions in the best Danish womens' league. They managed to identify a gap of the physical form of the women's national team players to the physical form of players playing in the best Danish women's league based on physical test results. Furthermore, Andersson et al[14] found that elite female football players perform better on different match performance metrics in international games compared to playing in domestic league games[14]. This may support the relevance of examining players at international level playing for their national team. However, the competitive demand differences between age categories in players competing at top-level at

international tournaments is still a gap in the current literature. Only one study has examined the position specific demands in U17, U20 and senior women national football teams during international competitions[16]. In the present study a significant difference were often found between U17 and U19 as well as between U17 and the A-team on the various acceleration and deceleration intervals at several playing positions. In addition, A-team players also performed significantly more L_{acc}, M_{acc}, H_{acc} and L_{dec} per minute at all positions compared to U17 players, this was also the case at M_{dec} for all positions except CM. Finally, it is relevant to mention that only the A-team's CB performed a significant higher amount of L_{dec} per minute than U19. Otherwise no significant difference were found between position from A-team and U19 at any other acceleration or deceleration metrics. Ramos et al[16] found several different playing positions at senior women's Brazilian national team to perform a greater amount of accelerations and decelerations than U20 players and U17 players. Furthermore, all U20 players except CB managed to cover a greater sprint distance, perform a greater amount of accelerations and decelerations than U17 players. Kobal et al[24] found professional female football players to perform a greater number of accelerations and decelerations compared to U17 and U20 at national Brazilian championships. These difference between senior and youth in existing literature and the present study can be explained by aging development of the biological motor unit abilities[40]. Long-term training and experience in strength and power production can improve the ability to perform accelerations and decelerations[41]. This is supported by studies investigating differences in physical performance tests which examines the power capacity. Doyle et al[19] found senior female players to perform higher counter movement jumps and show higher levels of reactive strength when comparing with U17 and U19 players. Furthermore, Mujika et al[42] reported a better agility test performance in high-level senior female players compared with youth players at 16–19 age. Considering these findings, this may suggest that power capacity and strength should be prioritized in training for youth in order to prepare for the demands at senior level by optimizing the ability to better perform accelerations and decelerations. Change of direction reflects the ability to do extreme decelerations and accelerations. This skill can be training through plyometric training and different kinds of sprint training[43][44].

As mentioned above, maximum acceleration and deceleration causes high metabolic and mechanical stress which puts a great workload on the individual during a match[35][36][37]. U17 players perform a lower amount of H_{acc} compared to the A-team across all playing position. Likewise did CM and WM at U17 perform a smaller amount of H_{dec} compared to the A-team. These results may indicate that playing at the A-team requires a greater ability to accumulate more external load, especially when playing in the wider areas of the pitch.

This may also indicate that by promoting U17 players to a higher level, it is important to understand that the player can be exposed to a higher work load than usual, especially on the wide side of the pitch. Additionally, the results show that the physical demands of accelerations and decelerations are similar at U19 and the A-team and therefore indicate that the work load in these matches may be similar with regard to these metrics. It is important to mention that a limitation of this study is the inability to measure other movements like tackles and jumps which might cause a high amount of work load as well. This study only investigated some of the metrics contributing to the total external work load of a player during a match.

Overall, the present study's findings emphasize the importance of understanding the difference in physical demands and characteristics of different positions at different ages. This can support coaches in optimizing training strategies and improving overall performance in specific positional roles.

C. Limitations

Some limitations needs to be considered when interpreting the findings of this study. Certain variables such as playing formation can impact the movement patterns of the player. Bradley et al[4] found that playing formation such as 4-3-3 and 4-4-2 had an impact on the movement patterns at different high intensity running intervals and total distance. These findings describe the importance of the effects of playing formation when analysing the different physical demands between playing positions. This problem also occured when comparing the danish national teams. The youth teams typically played a 4-3-3 while the adult team always played with a 3-4-3 formation. Another limitation is the selection bias of each player's playing position. There is a chance that the position of a player might chance during a match[45]. The playing formation of the A-team might have been a limiting factor as well in this study as it was not possible to identify a FB, because of the formation. The area on the pitch normally covered by a FB would then probably be covered by a CB and/or a WM which would influence the demands of these two positions. Different factors such as the level of competition, the opponent, the scoreline, motivation or fatigue can be different from match to match and can change the movement patterns of a player[6].

Studies have found that distance covered, accelerations and decelerations is significantly lower in the last 15 minutes compared to the first 15 minutes of a match[30][29]. This might have influenced the results of the study as players playing above 75 minutes in a match were included and not only players playing full time. The decision of

including player playing less than full time was done by the authors in order to increase the power of the study. As the players playing less than full time would have lower total values caused by less time on the pitch it was decided to divide the values of distance covered, accelerations and decelerations with the number of minutes spend on the pitch by each player resulting in the metrics being "per minute" and not "per match". A consequence of this could be an overestimation of the demands as it is well known that the intensity decreases in the last phases of a football match[30][10].

V. Conclusion

This study was able to identify a general increase in physical demands during international competitive matches from U17 to U19 and senior level. The biggest increase happened in the transition from U17 to U19 and not from U19 to senior level. Especially the demands of performing accelerations and decelerations differed from U17 to U19 and the A-team. Wide and attacking oriented positions (WM and FW) should be able to run a greater distance at high speed during a match compared to defensive and central players (CB and CM) when playing in the A-team.

- The amount of accelerations and decelerations performed during international matches increases from U17 to the A-team. A way to prepare the players for these greater demands could be by implementing training drills improving change of direction. In order to change direction, the player needs to decelerate and accelerate at a very high degree. Plyometric training and sprint training have been found to increase the change of direction skill.
- When reaching adult level, WM has to be able to cover a greater distance per minute in the speed zones 15+, 18+ and 25+ kph compared to other outfield playing positions. The demands of running capacity is higher than other positions, and therefore should the position specific training of a WM, have a greater focus on endurance and the training should be planned with this in mind.

VI. Further studies

It could be interesting to investigate how well currently used physical performance tests predict match performance in female soccer players in different positions and age groups. This could involve comparing test results with match performance data to determine how well these tests predict performance, and whether any modifications to the tests or evaluation criteria might be necessary.

Furthermore, by comparing the physical capacity between national team players and non-selected players it would be possible to determine whether physical capacity is used as a selection criterion for the national team.

Additionally, it could be worthwhile to examine whether a causal relation exists between changes in physical capacity and match performance, respectively based on evaluation of the Yo-Yo intermittent recovery test Level 1 (YYIR1).

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VII. Appendix

A. Method

Firstly, a document was created containing all international matches played by the Danish youth and adult national teams in the period January 2020 - March 2023. All data was collected from "Landsholdsdatabasen"[25]. The following data was registered in the document: date, opponent, result, home-/away match, friendly match or competitive match and whether it was decided in regular time, overtime or by penalty shootout. Then data for the players was collected from all competitive matches played by the Danish national teams in the above mentioned period. The authors were given access to the data from Polar Team Pro by the Danish Football Association. The first and second half of the matches were manually marked by the authors. In order to identify the beginning and end of each half, four to five full time players were selected. Then the beginning of the first half was estimated based on the planned starting-time of the match as well as the velocity and position of the player. A map in Polar showed the players' current position on the pitch at different time points during the match. After each half were marked, the data from both halfs was exported as an excel file.

The variables extracted from Polar included: player name, player number, duration of the interval (first and second half), total distance, top speed, number of sprints, distance covered at different speed zones (6.00 - 11.99 kph, 12.00 - 14.99 kph, 15.00 - 17.99 kph, 18.00 - 24.99 kph, 25.00+ kph), number of decelerations (-50.00 - -5.00 m/s^2, -4.99 - -3.00 m/s^2, -2.99 - -1.50 m/s^2, -1.49 - -0.50 m/s^2) and number of accelerations (0.50 - 1.49 m/s^2, 1.50 - 2.99 m/s^2, 3.00 - 4.99 m/s^2, 5.00 - 50.00 m/s^2). Distance covered at a speed above 15 kph was calculated by adding the distance covered in the three fastest speed zones (15.00 - 17.99 kph, 18.00 - 24.99 kph, 25.00+ kph). In the same way, distance covered above 18 kph was calculated by adding distance covered in the two fastest speed zones (18.00 - 24.99 kph, 25.00+ kph). The greatest decelerations (-50.00 - -5.00 m/s^2 and -4.99 - -3.00 m/s^2) were combined as were the greatest accelerations (3.00 - 4.99 m/s^2 and 5.00 - 50.00 m/s^2).

Three extra columns were added to the excel sheet. These columns were used to register number of minutes played during the match for each player, playing position and whether the player was in the starting line-up or came on as a substitute. Playing position was identified by the line-ups found on UEFA's website[26] which were compared to the line-ups from each team's official Facebook-site in order to secure the correct playing position of each player. Full match data was then calculated for each player by adding the value from the first half with the value from the second half. For the column containing top speed during the match, the highest value was used for analysis. All data except top speed were then divided with the number of minutes the player participated in the match. Substitutes covered some distance while not being on the pitch. For this reason the authors chose to delete the data from halfs where the players did not participate in the match.

This procedure was done for every tournament match. After going through this procedure for every tournament match, data was collected from players participating at least 75 min of a match. These data were then used for statistical analysis.

B. Results

Radar charts

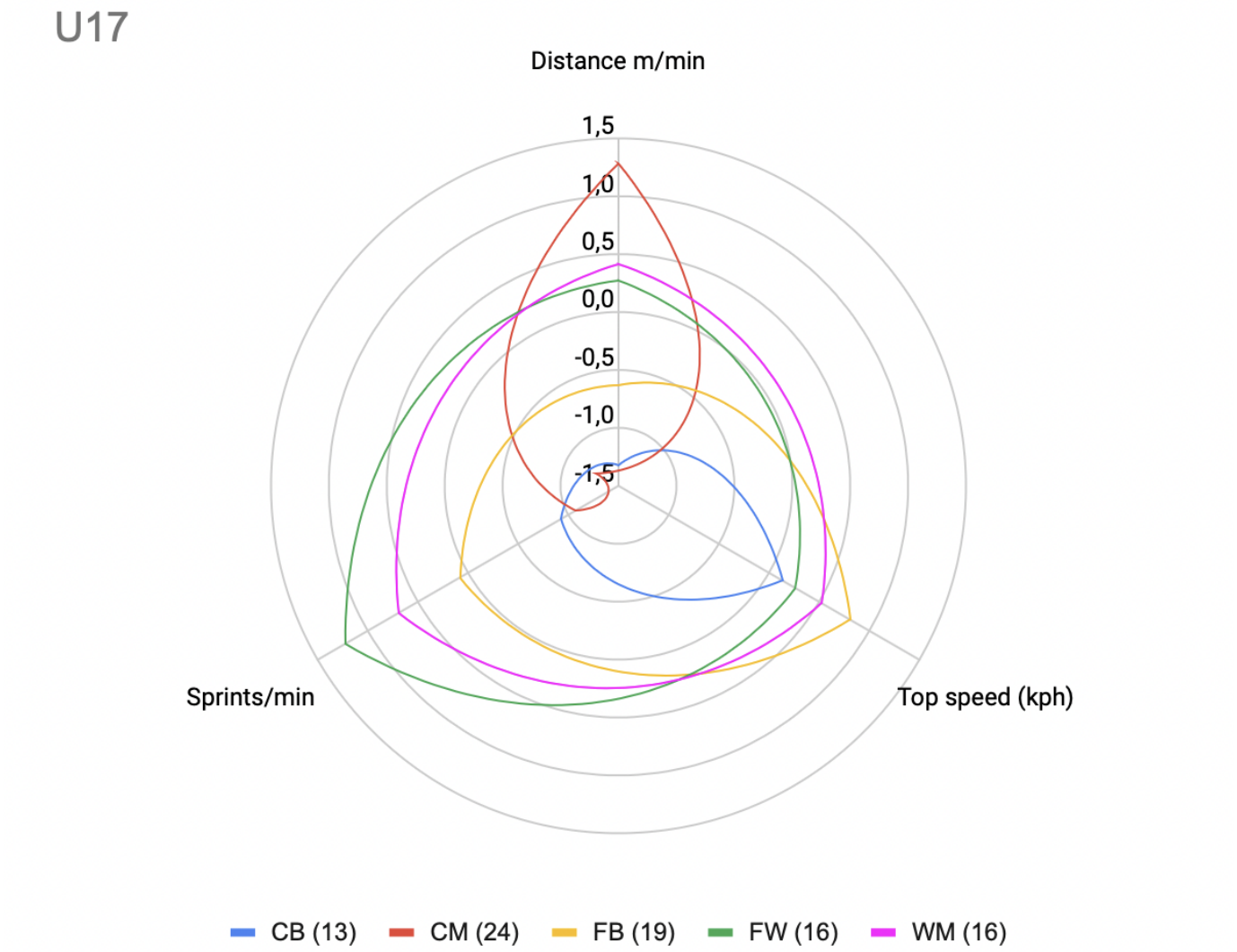

Figure 13. *Radar chart of number of sprints per minute, top speed and distance covered per minute for each playing position at U17 based on z-scores*

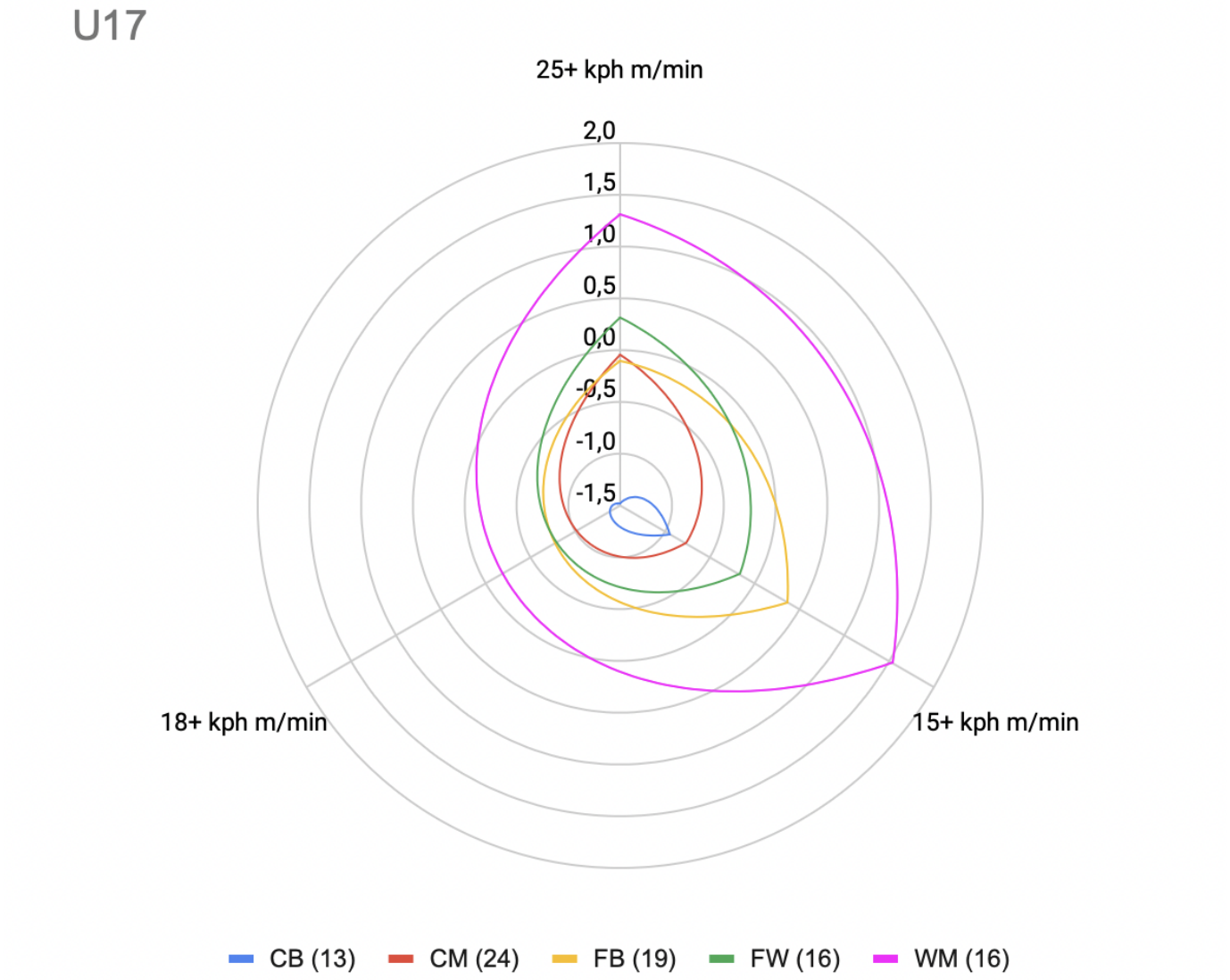

Figure 14. *Radar chart of distance covered per minute at above 15, 18 and 25 kph for each playing position at U17 based on z-scores*

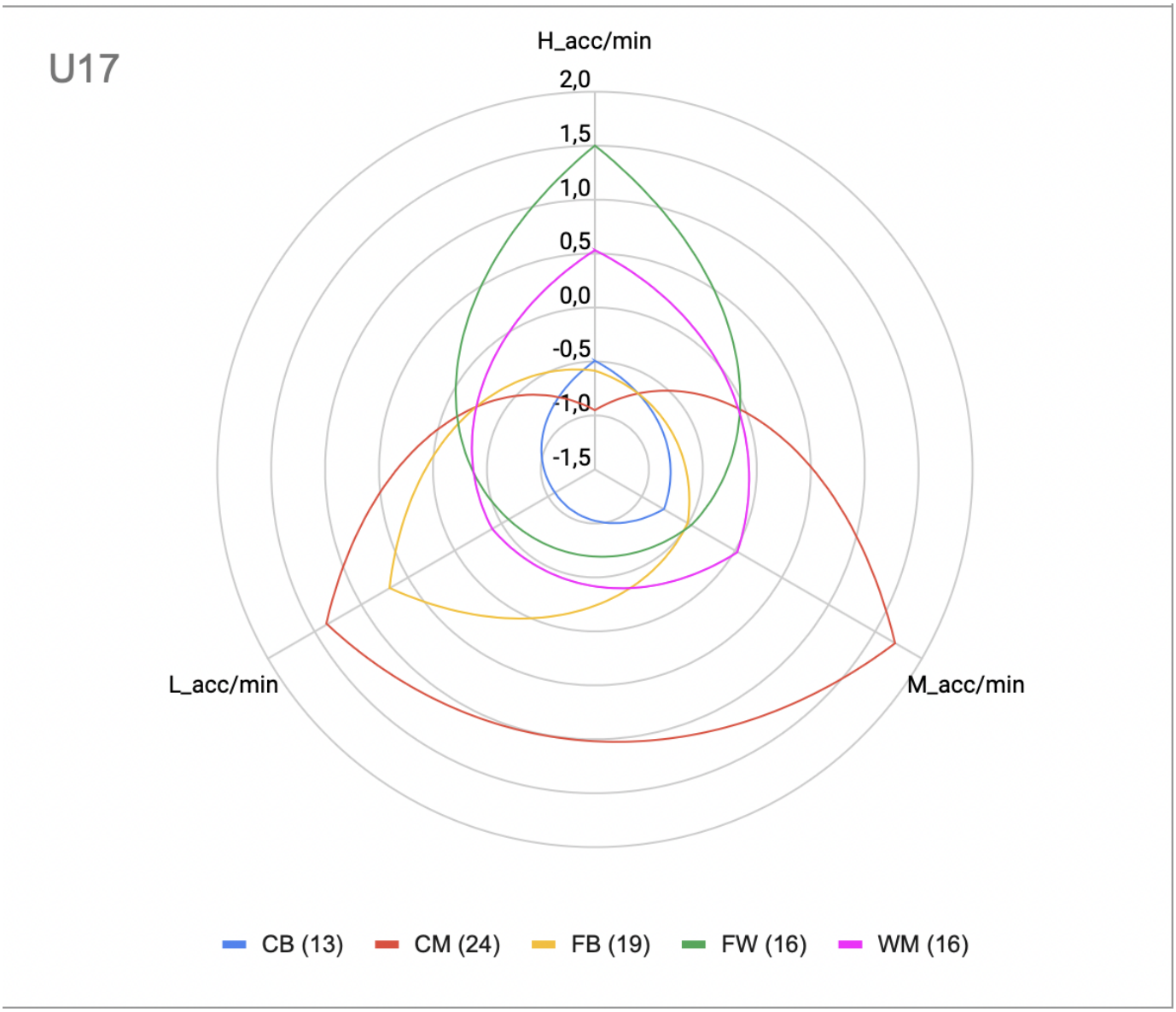

Figure 15. *Radar chart of number of low, moderate and high accelerations per minute for each playing position at U17 based on z-scores*

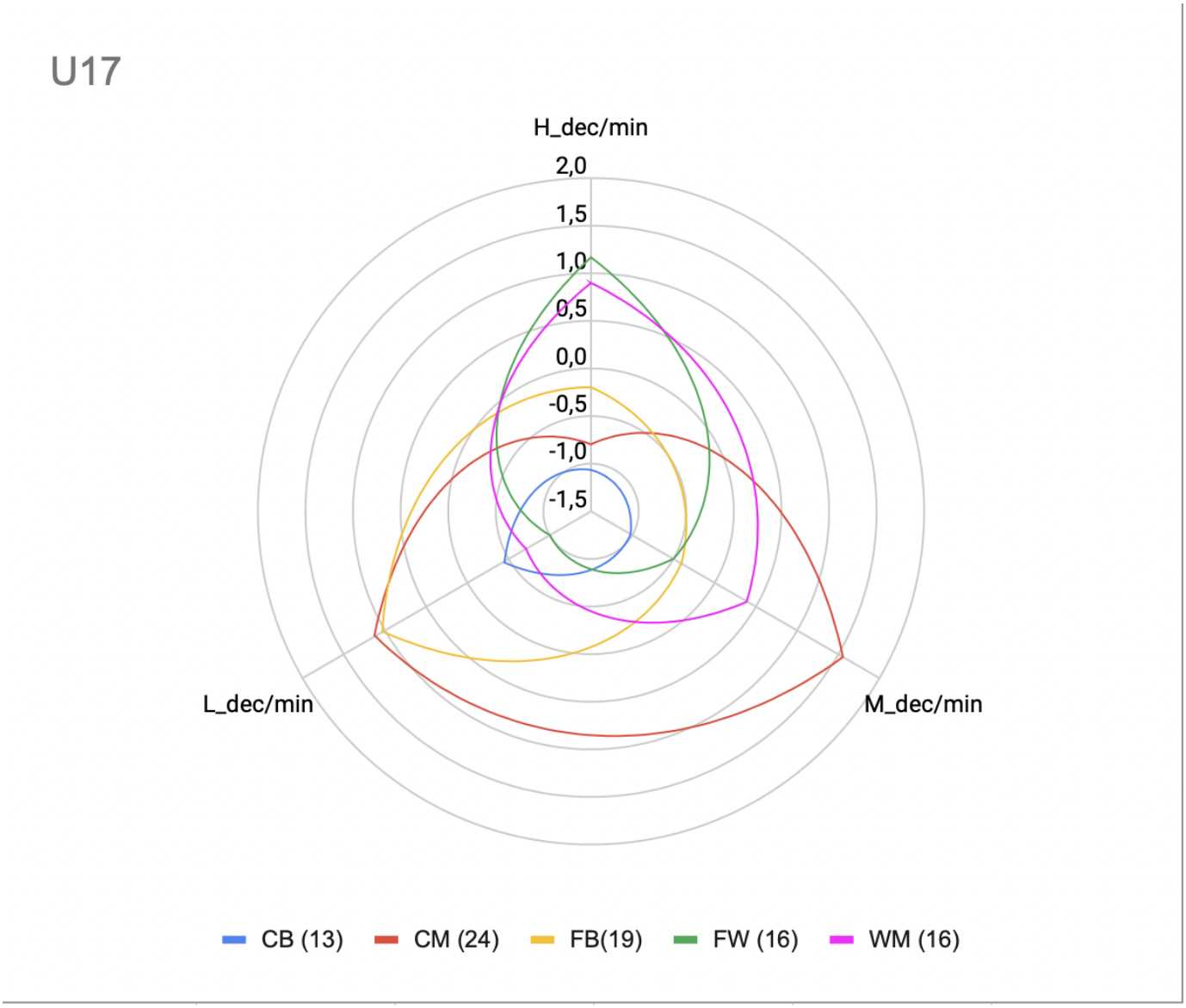

Figure 16. *Radar chart of number of low, moderate and high decelerations per minute for each playing position at U17 based on z-scores*

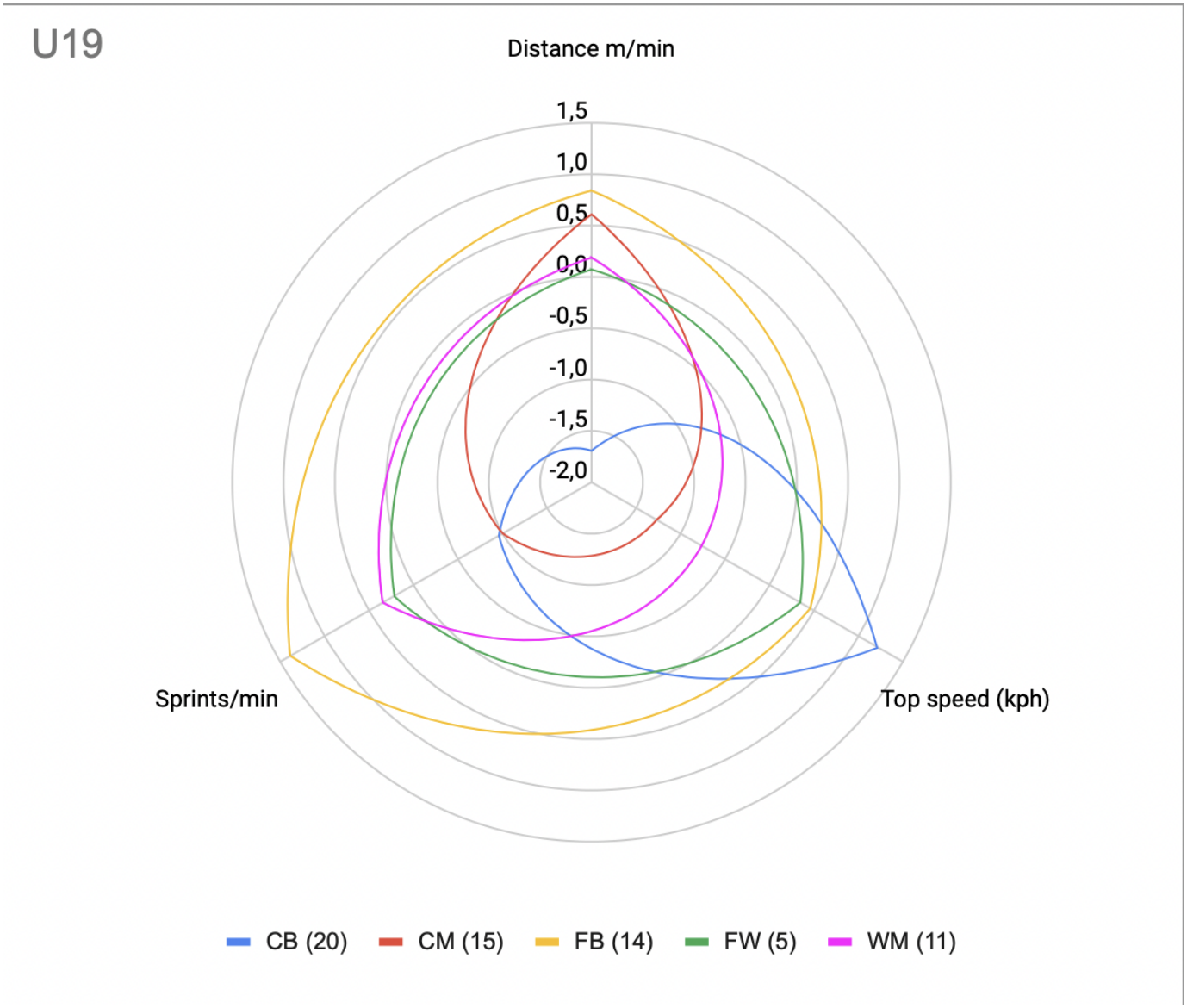

Figure 17. *Radar chart of number of sprints per minute, top speed and distance covered per minute for each playing position at U19 based on z-scores*

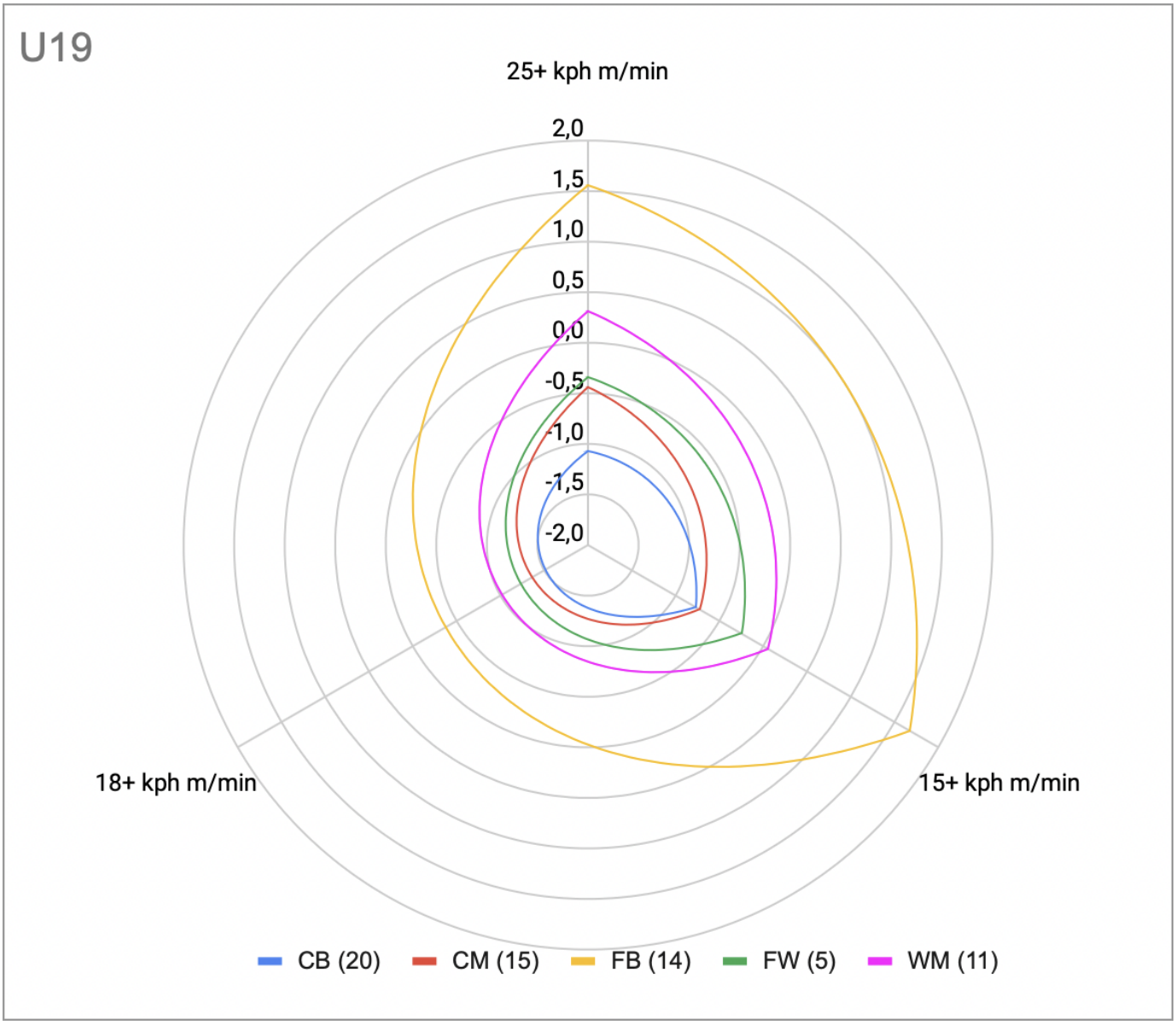

Figure 18. *Radar chart of distance covered per minute at above 15, 18 and 25 kph for each playing position at U19 based on z-scores*

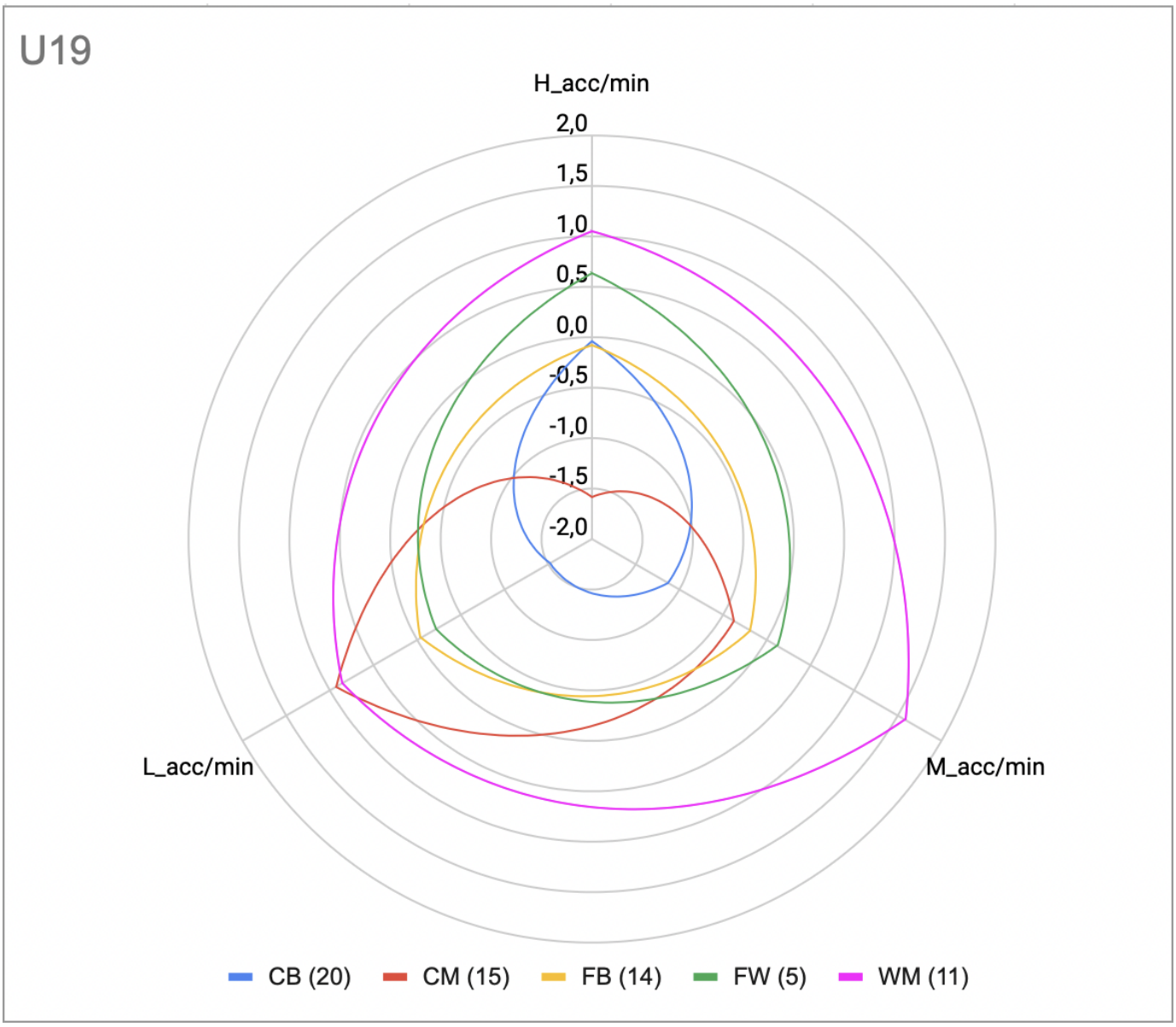

Figure 19. *Radar chart of number of low, moderate and high accelerations per minute for each playing position at U19 based on z-scores*

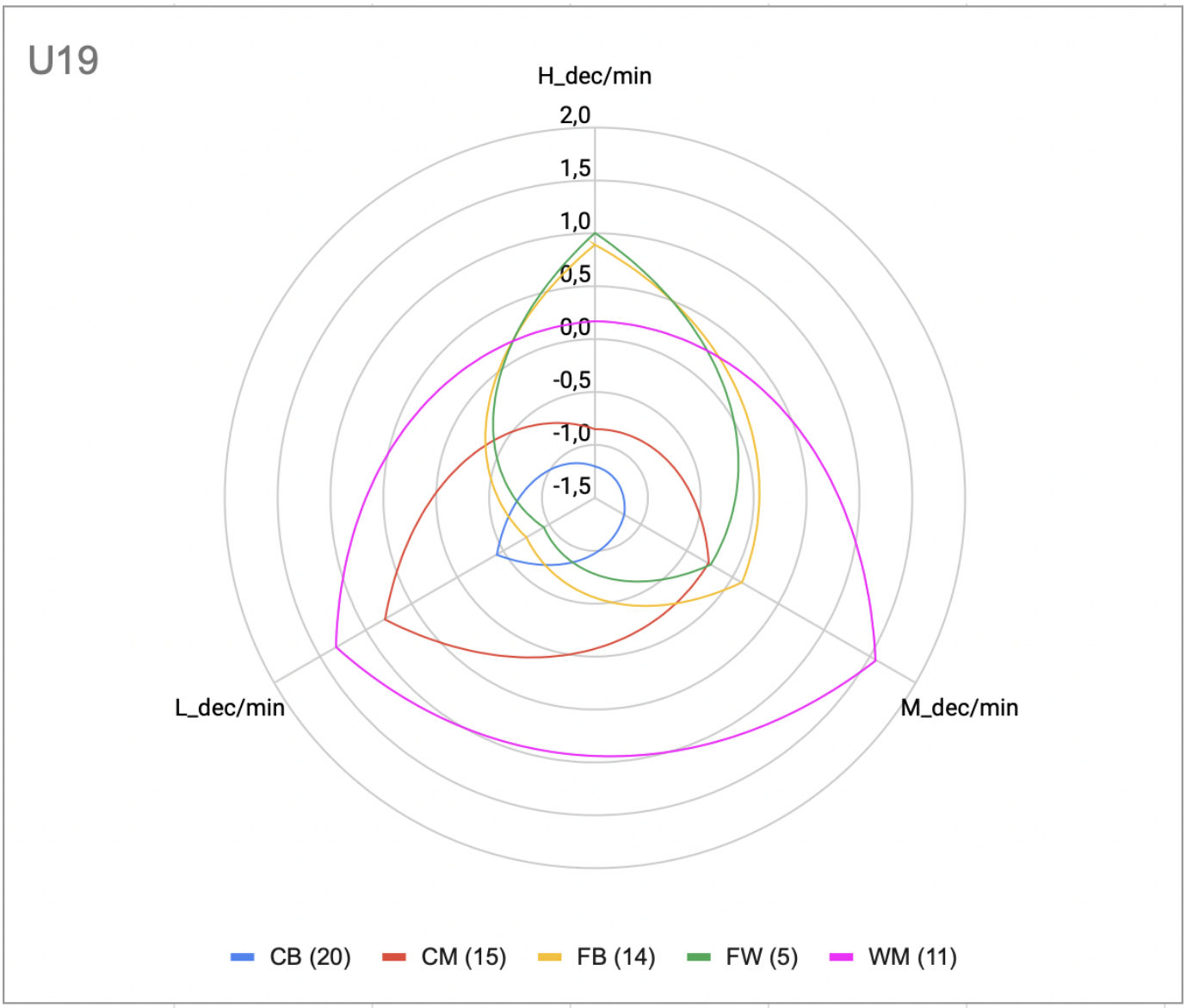

Figure 20. *Radar chart of number of low, moderate and high decelerations per minute for each playing position at U17 based on z-scores*

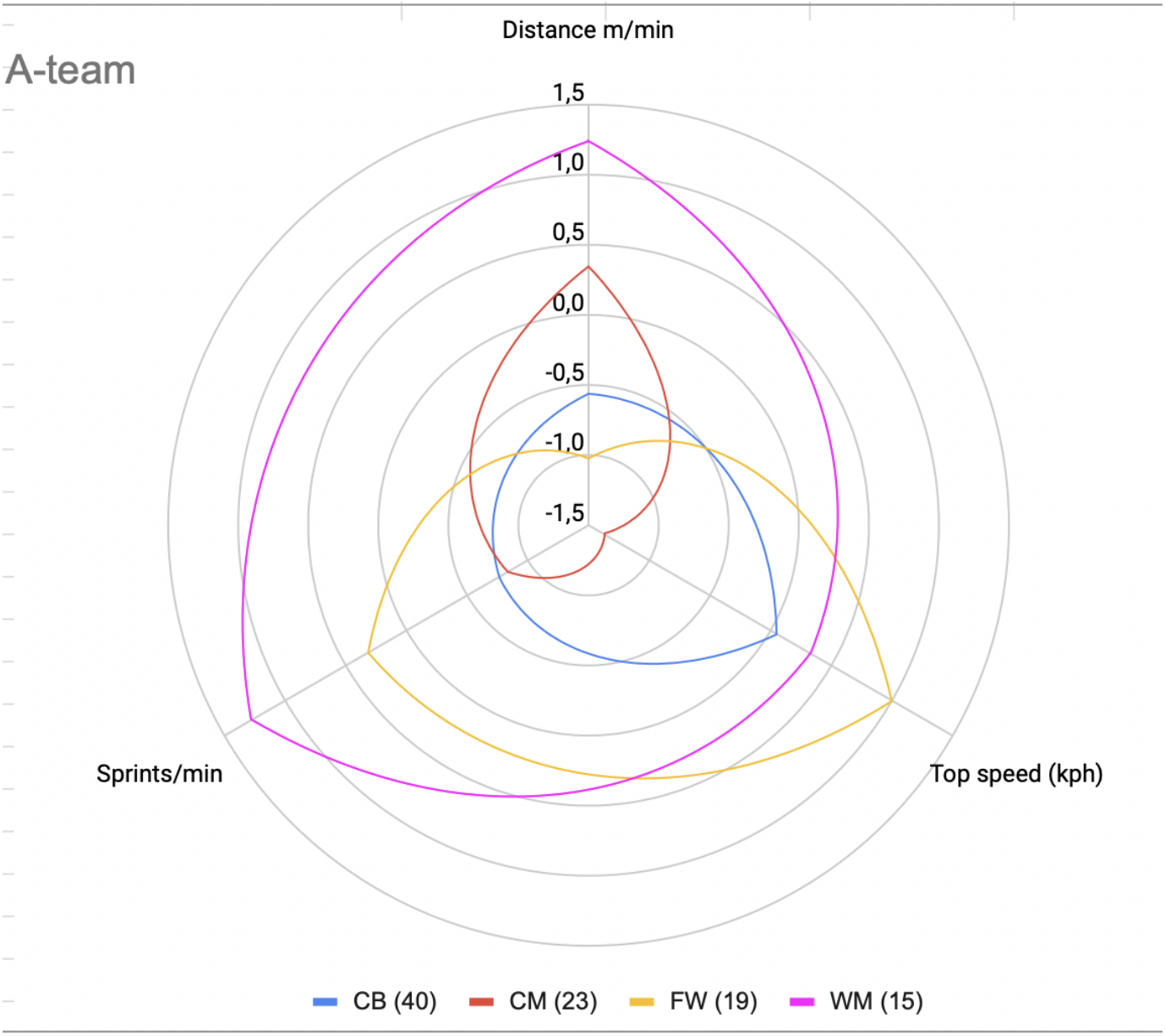

Figure 21. *Radar chart of number of sprints per minute, top speed and distance covered per minute for each playing position at the A-team based on z-scores*

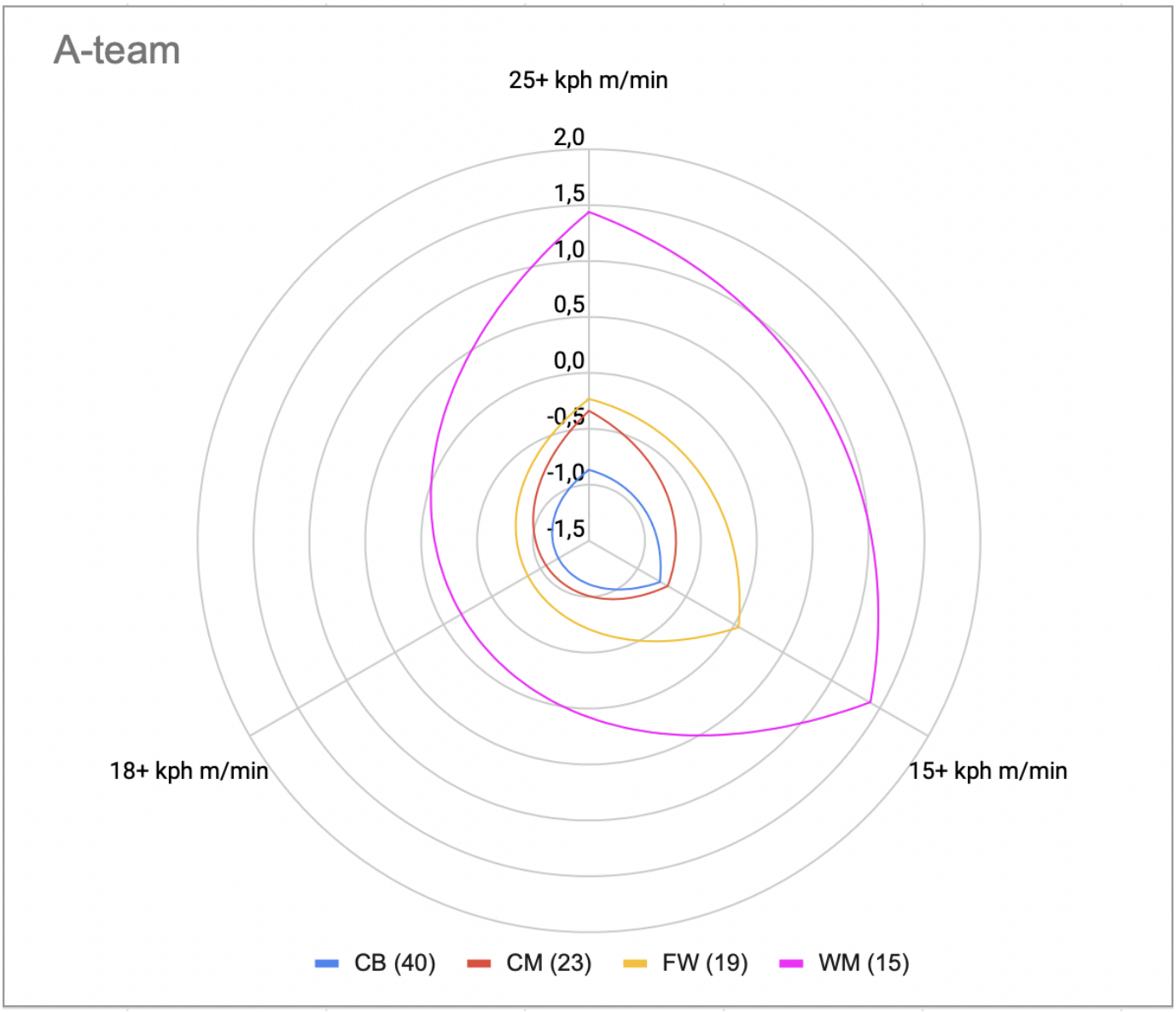

Figure 22. *Radar chart of distance covered per minute at above 15, 18 and 25 kph for each playing position at the A-team based on z-scores*

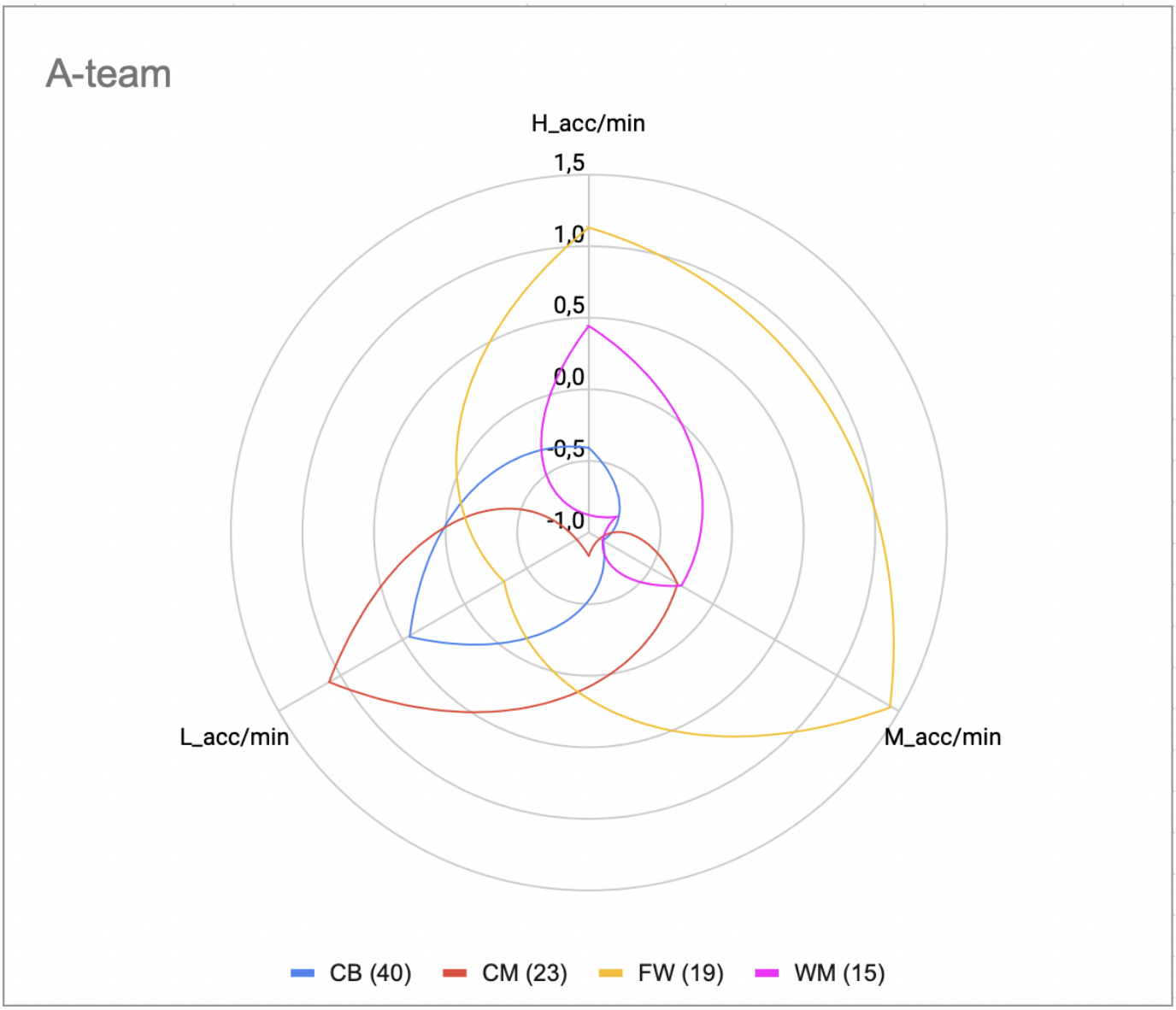

Figure 23. *Radar chart of number of low, moderate and high accelerations per minute for each playing position at the A-team based on z-scores*

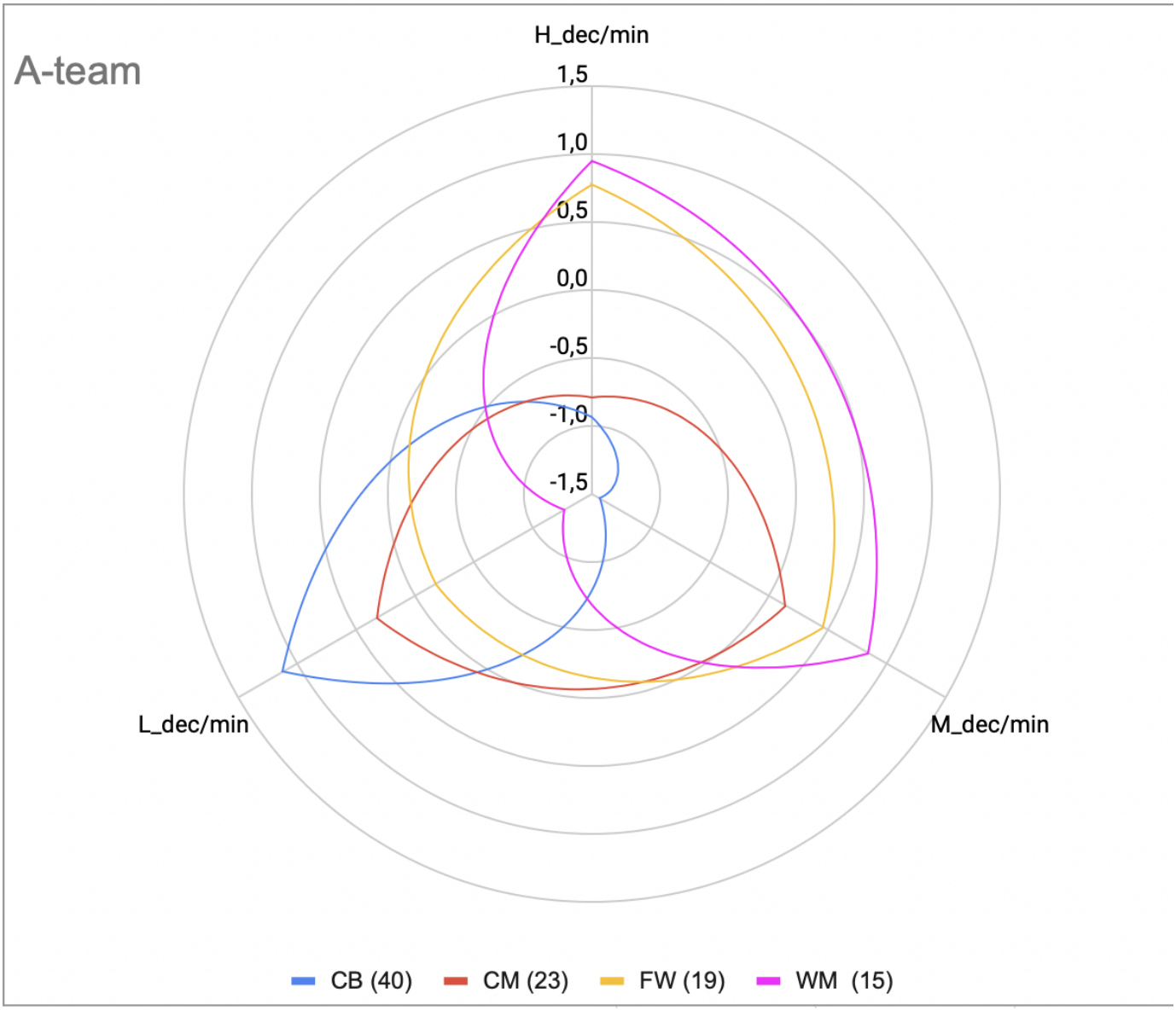

Figure 24. *Radar chart of number of low, moderate and high decelerations per minute for each playing position at U17 based on z-scores*

Physical demands across age groups

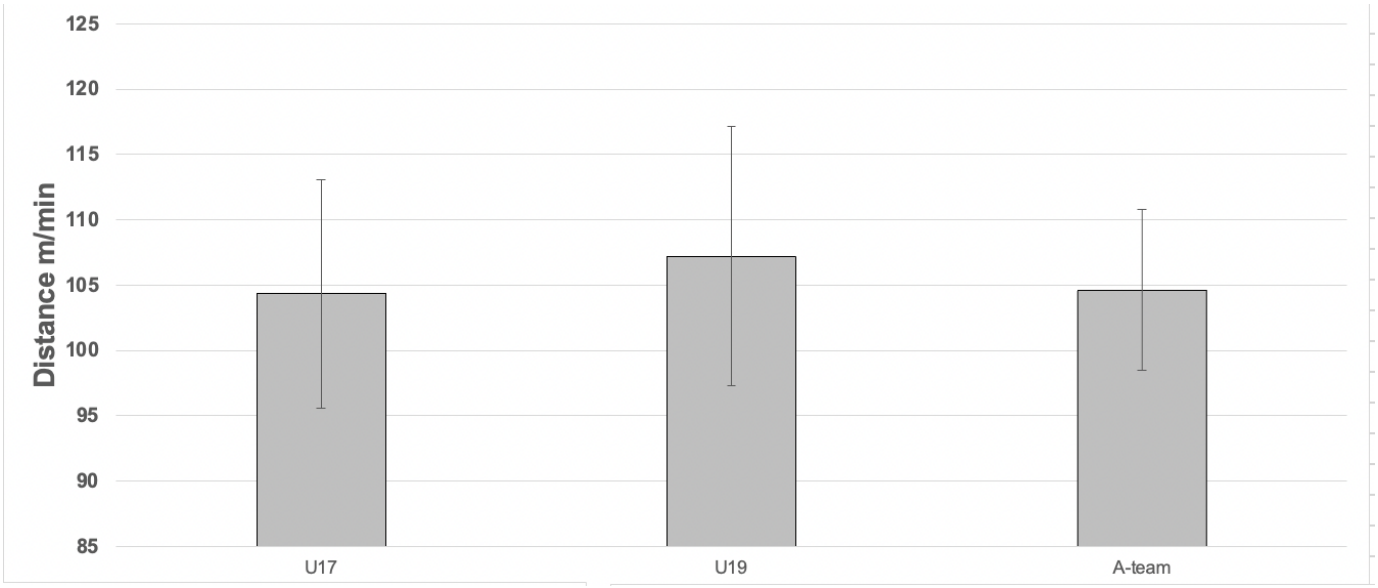

Figure 25. *Mean distance covered per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

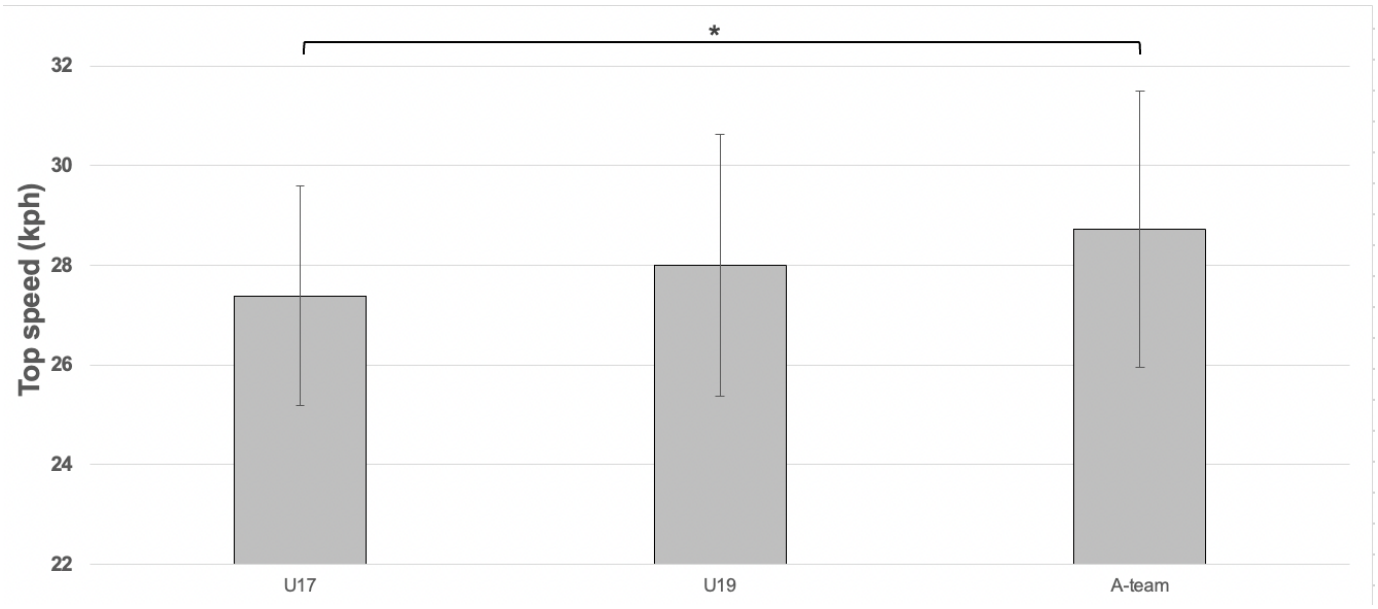

Figure 26. *Top speed of U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

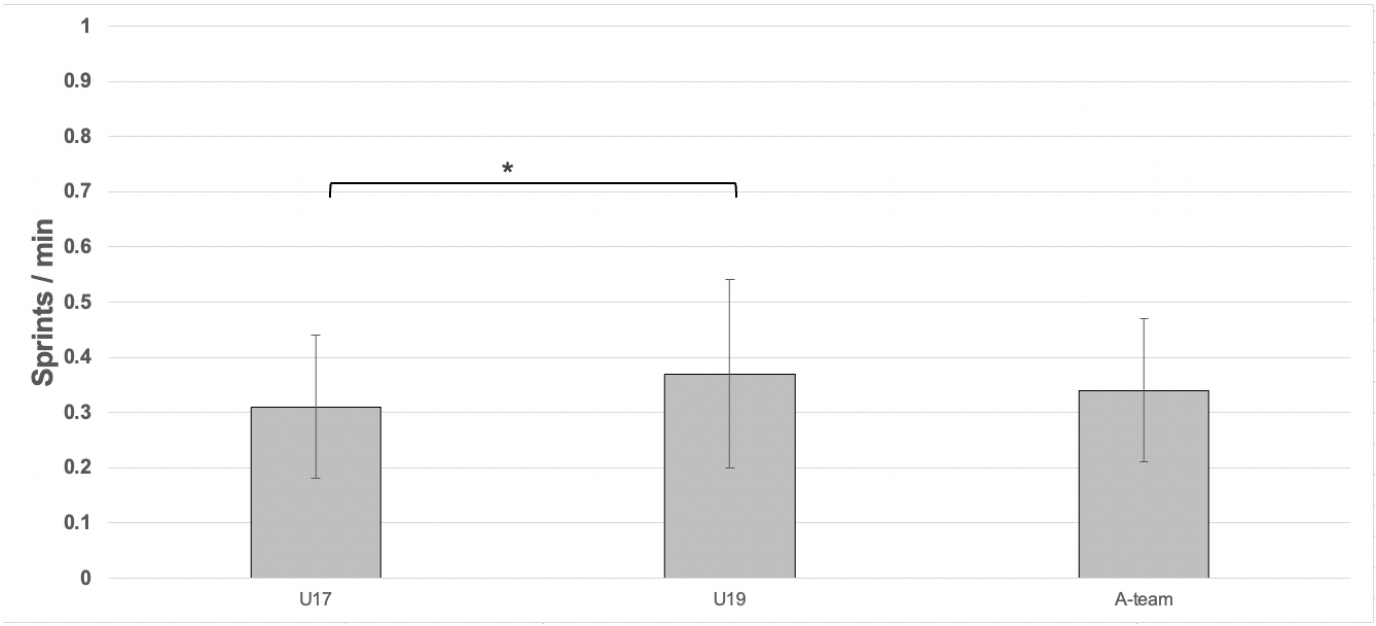

Figure 27. *Mean number of sprints per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

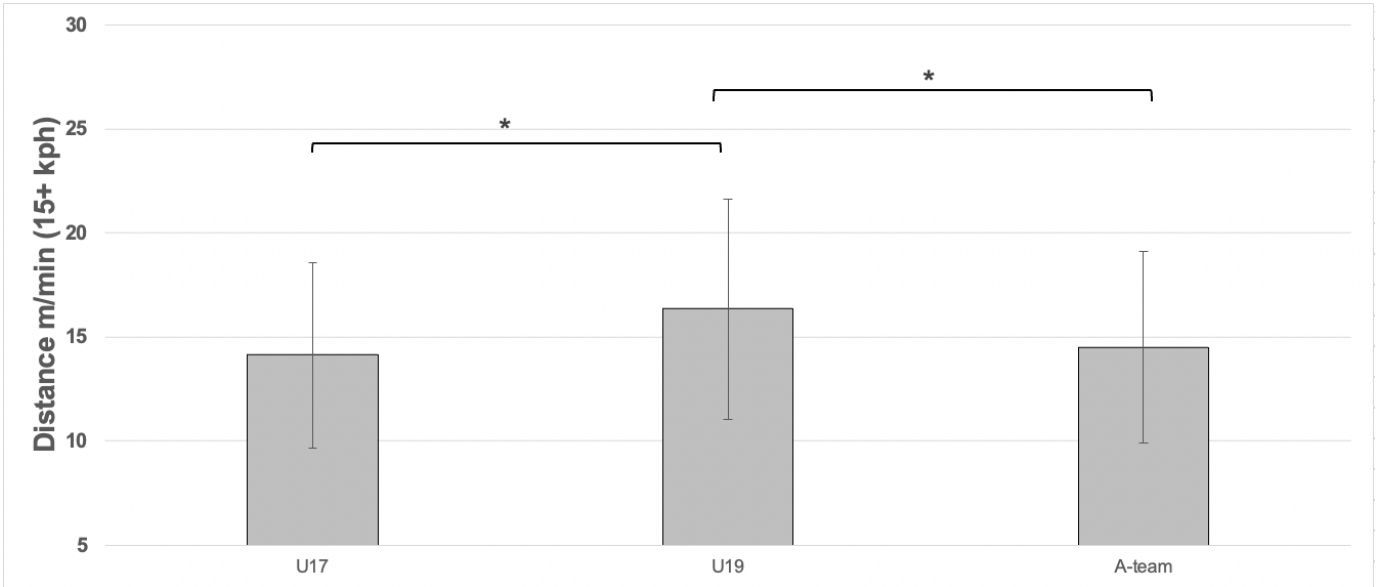

Figure 28. *Mean distance covered per minute at a speed above 15 kph by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

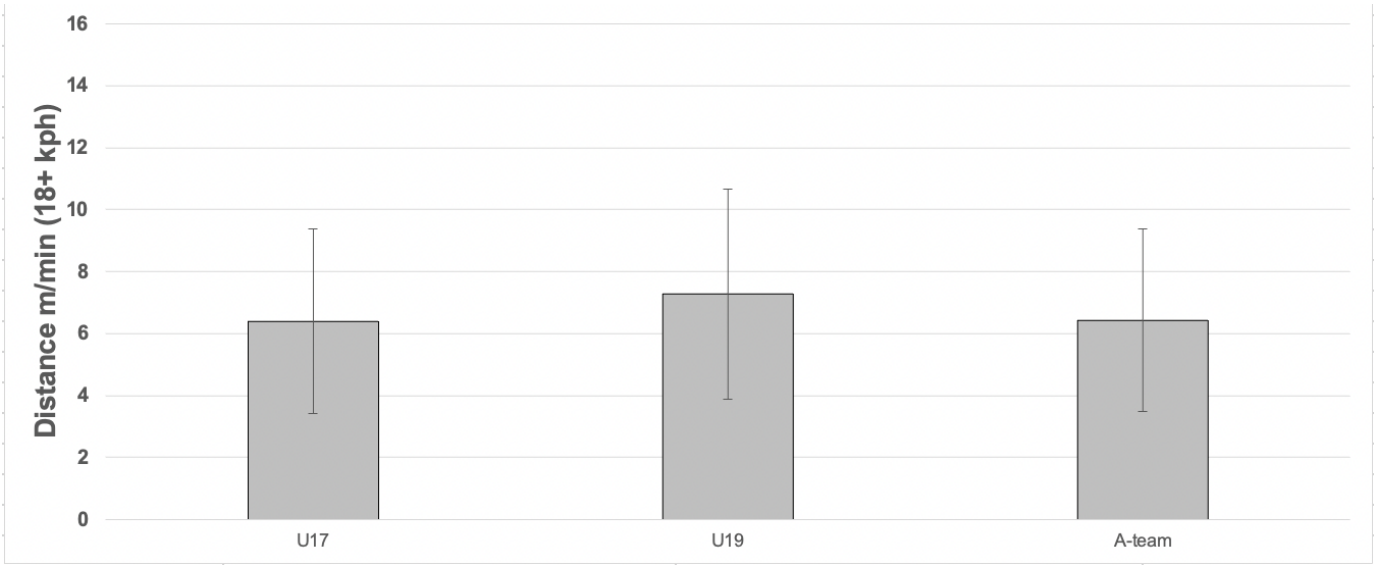

Figure 29. *Mean distance covered per minute at a speed above 18 kph by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

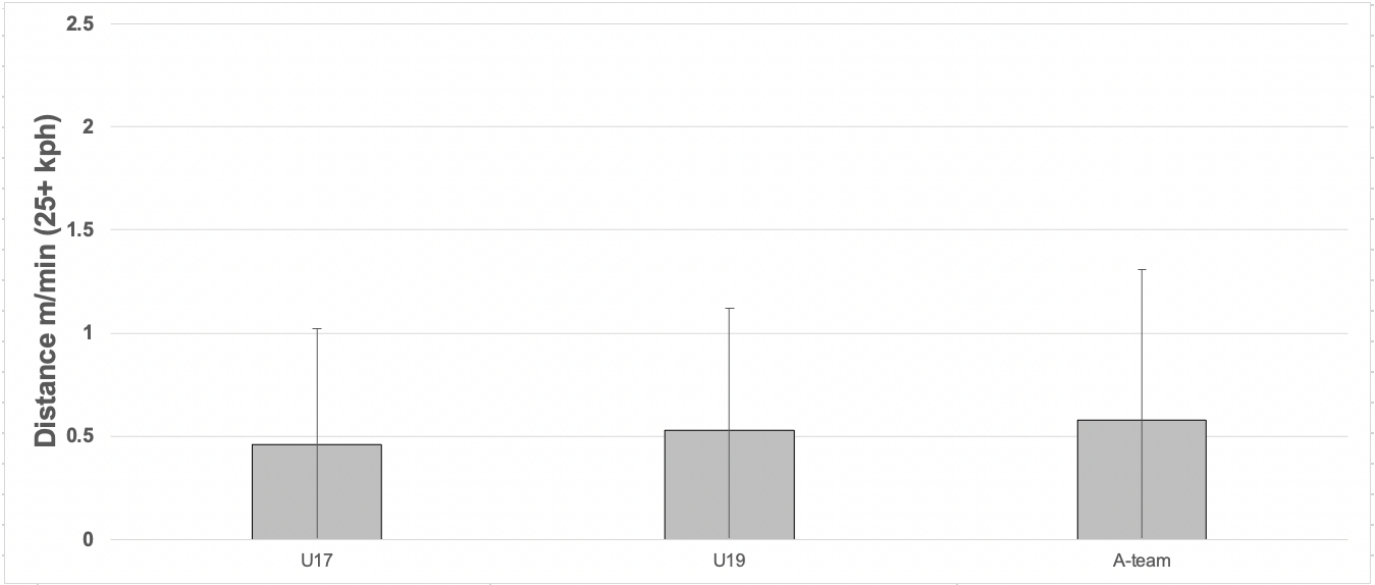

Figure 30. *Mean distance covered per minute at a speed above 25 kph by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

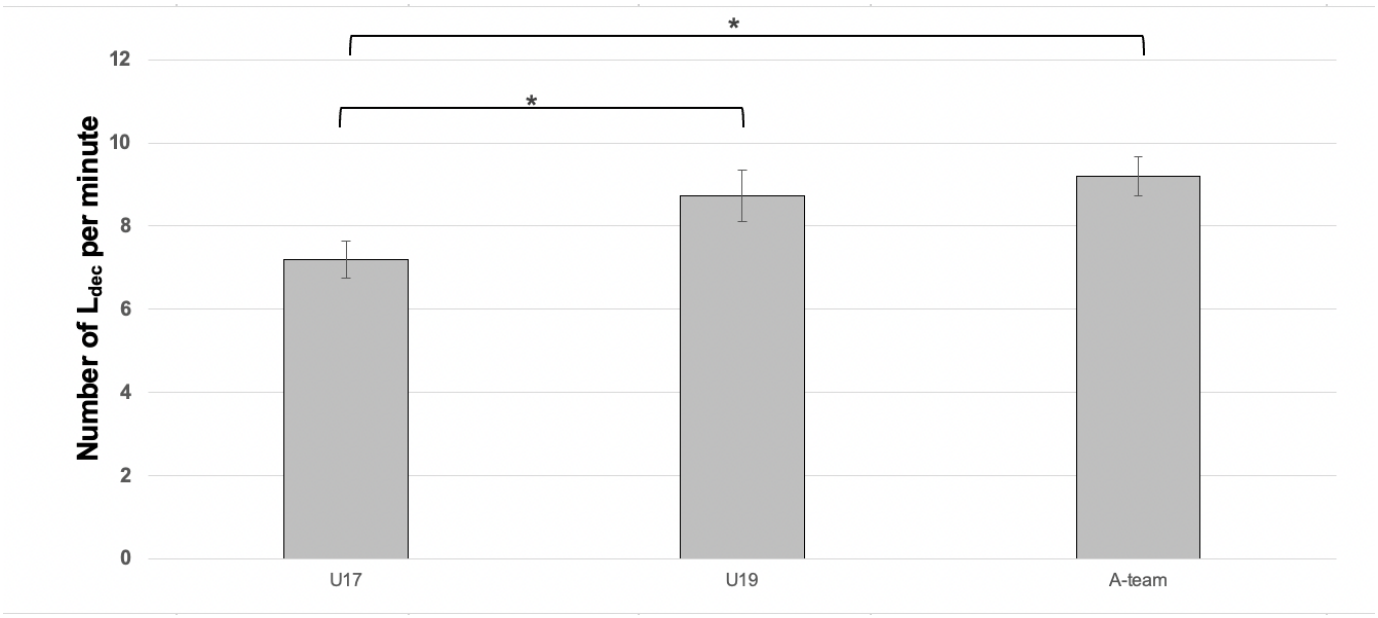

Figure 31. *Mean number of low decelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

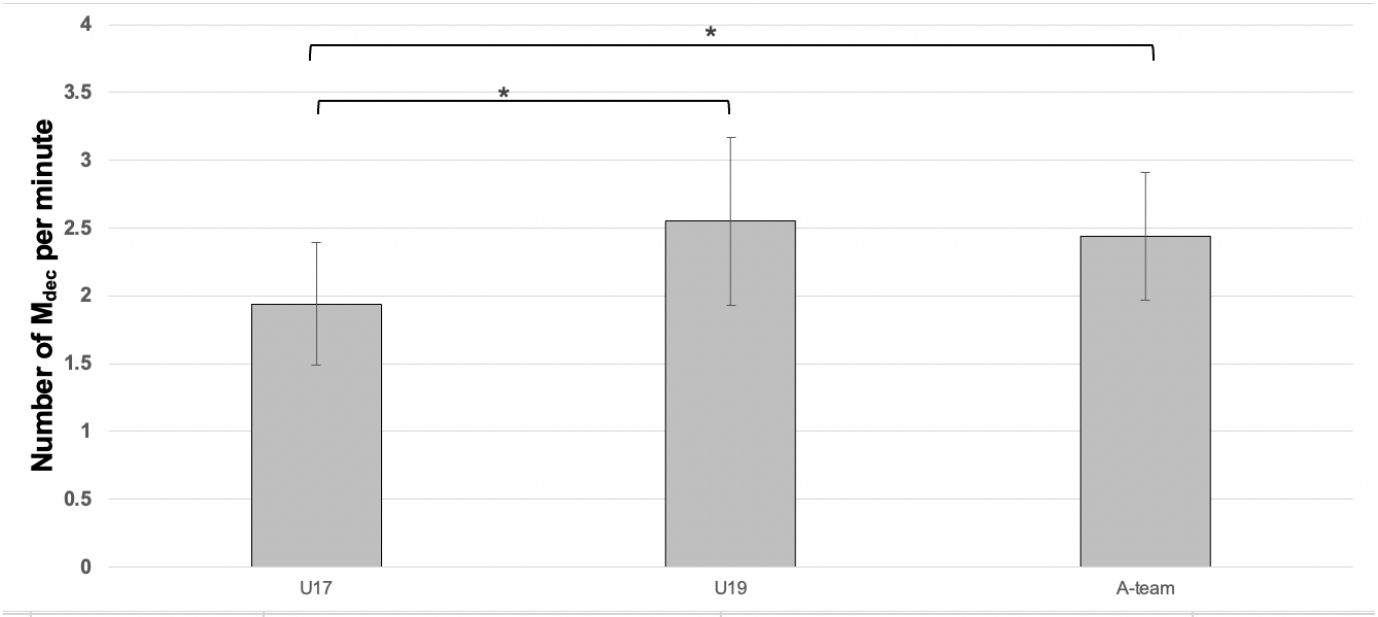

Figure 32. *Mean number of moderate decelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

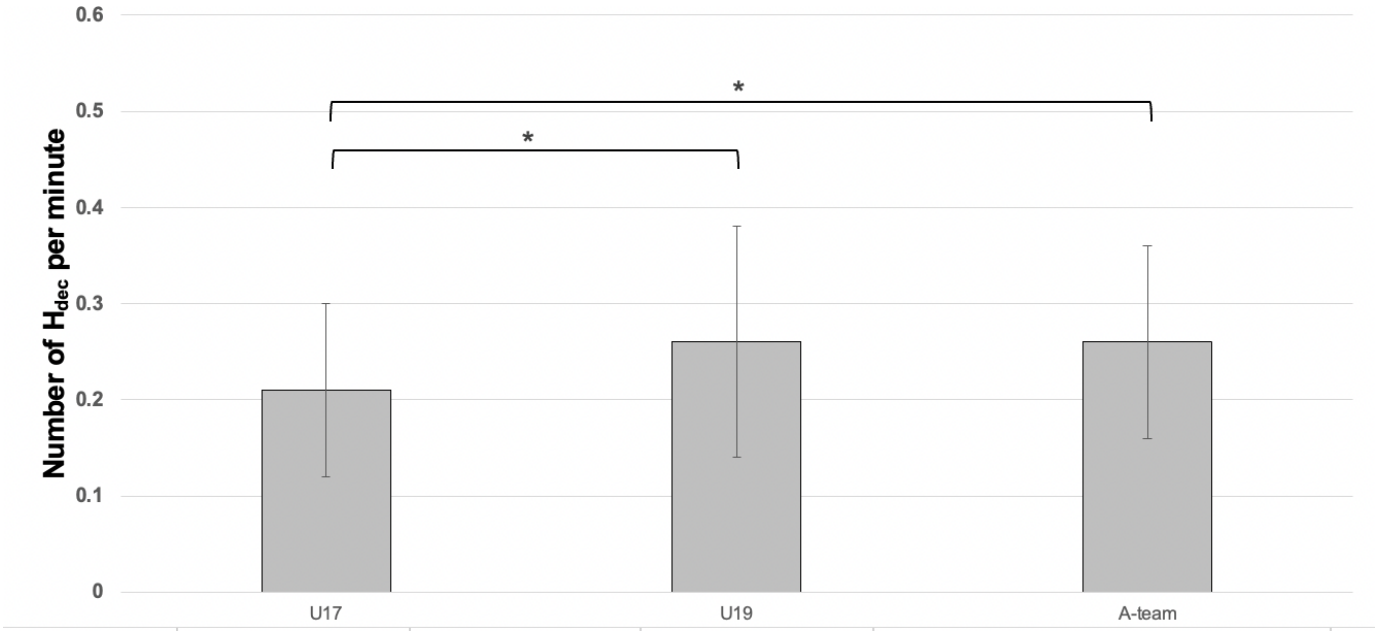

Figure 33. *Mean number of high decelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

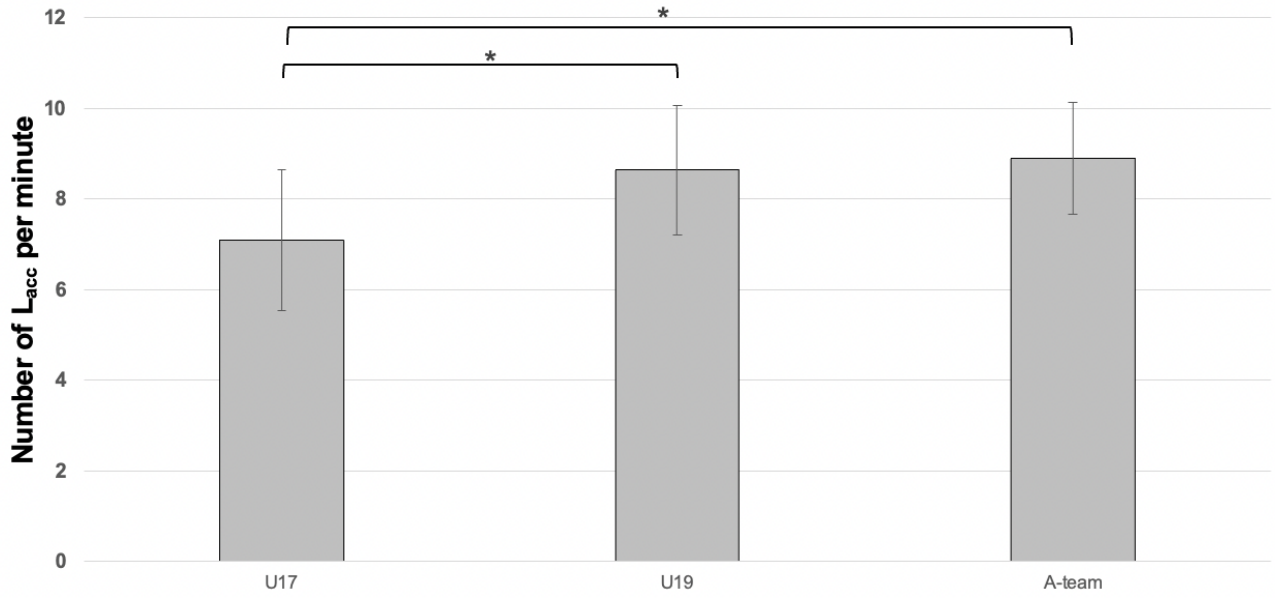

Figure 34. *Mean number of low accelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

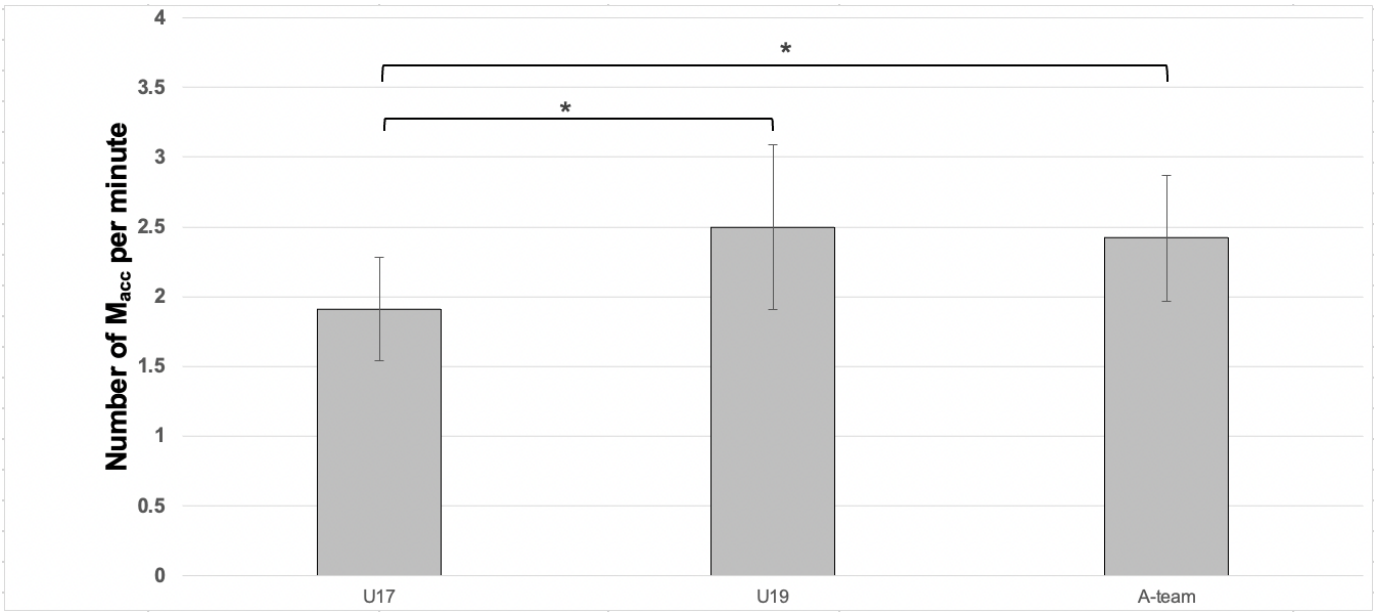

Figure 35. *Mean number of moderate accelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

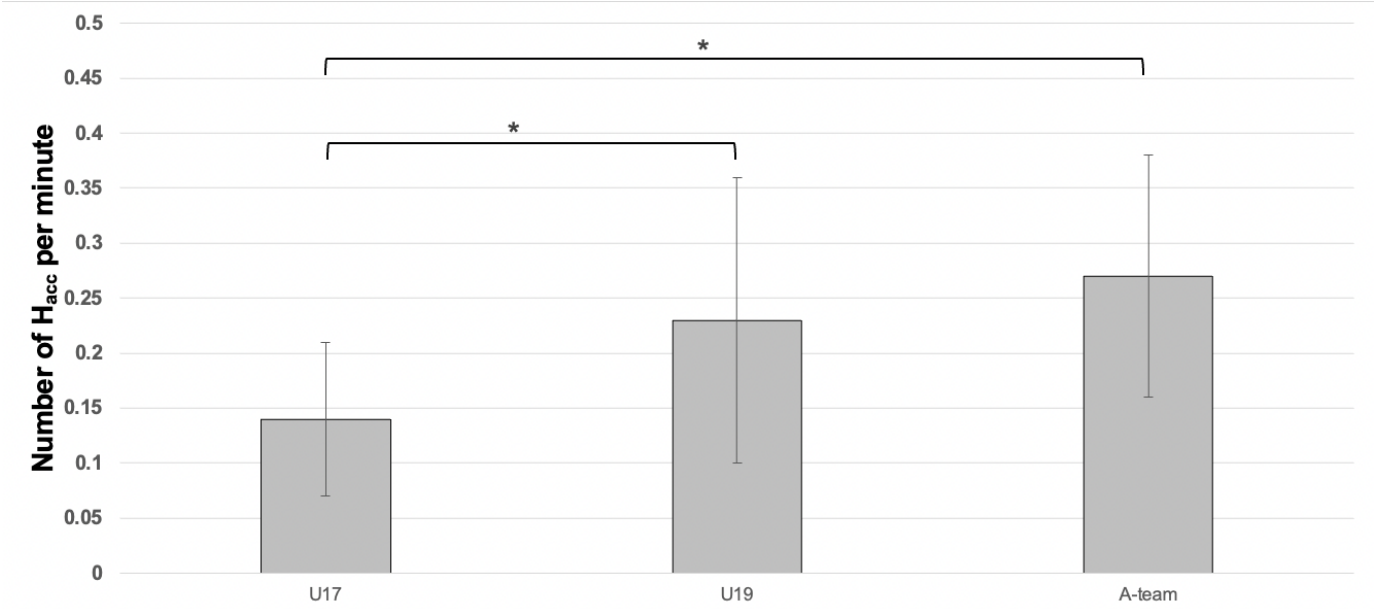

Figure 36. *Mean number of high accelerations per minute by U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

Comparison of each position between age groups

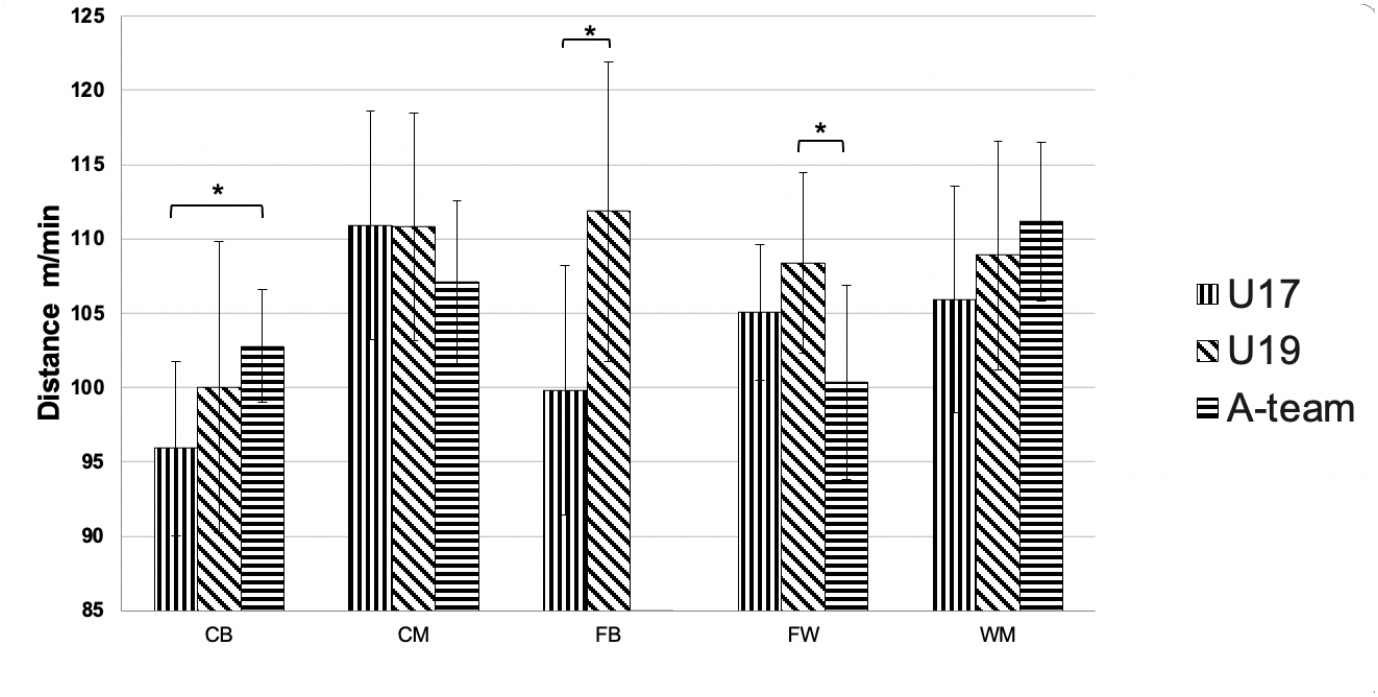

Figure 37. *Mean distance covered per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

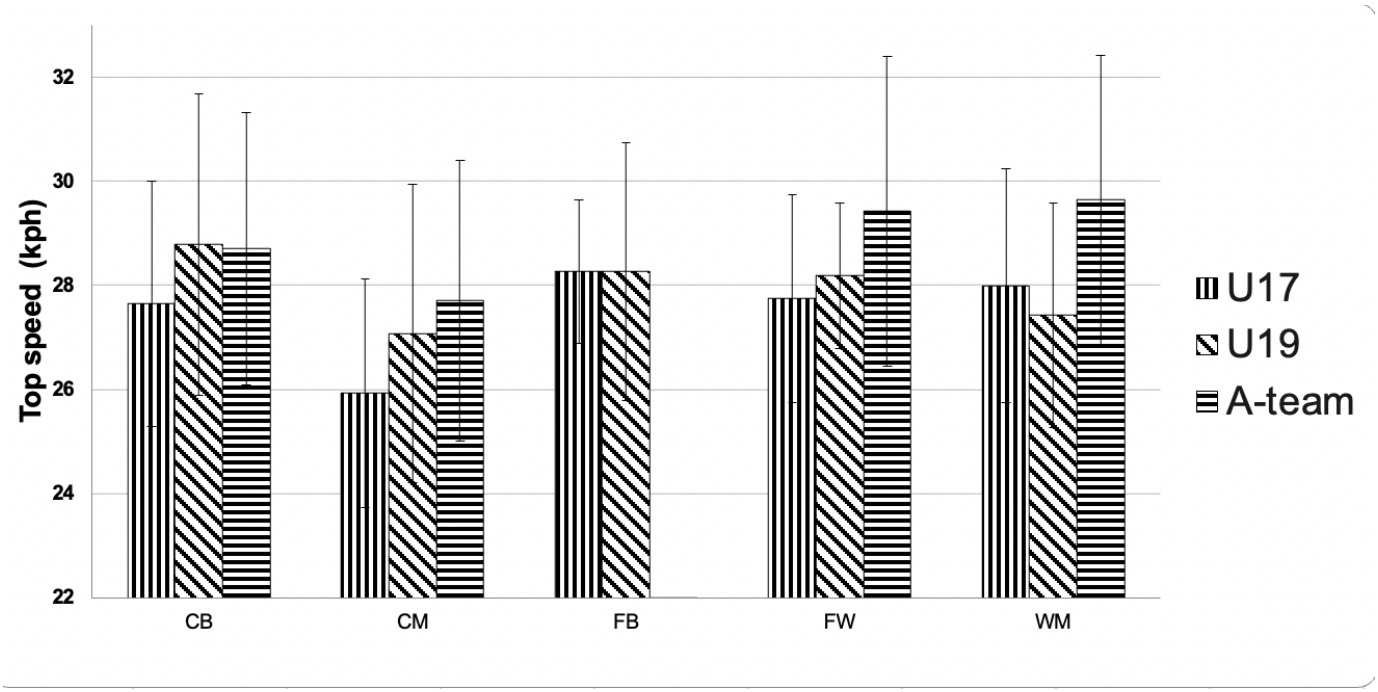

Figure 38. *Top speed between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

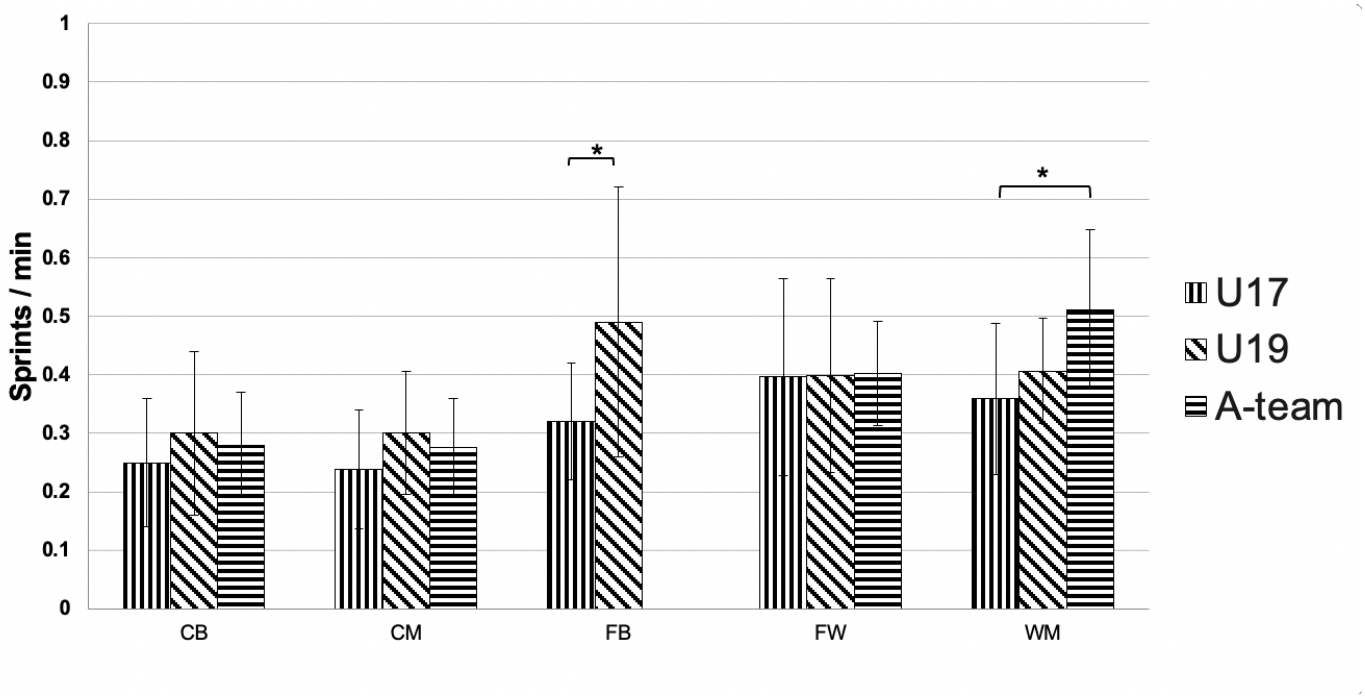

Figure 39. *Mean number of sprints per minute between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

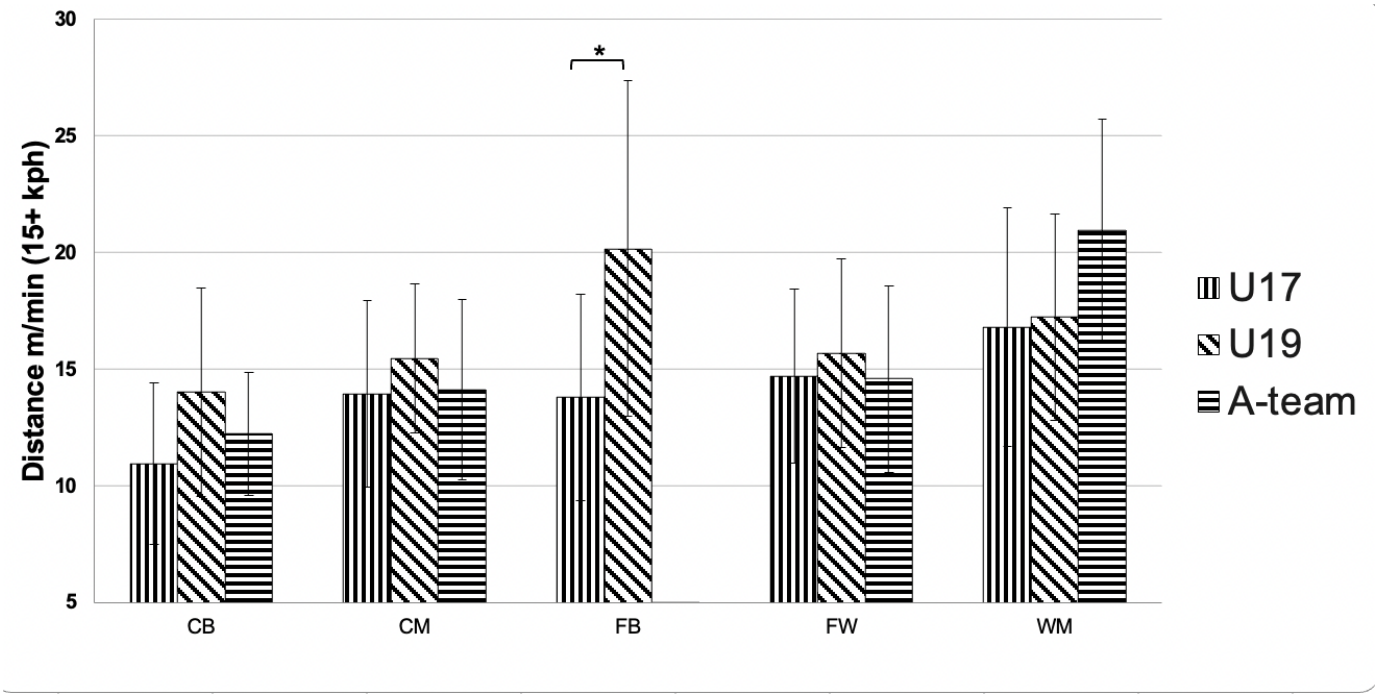

Figure 40. *Mean distance covered per minute at a speed above 15 kph between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

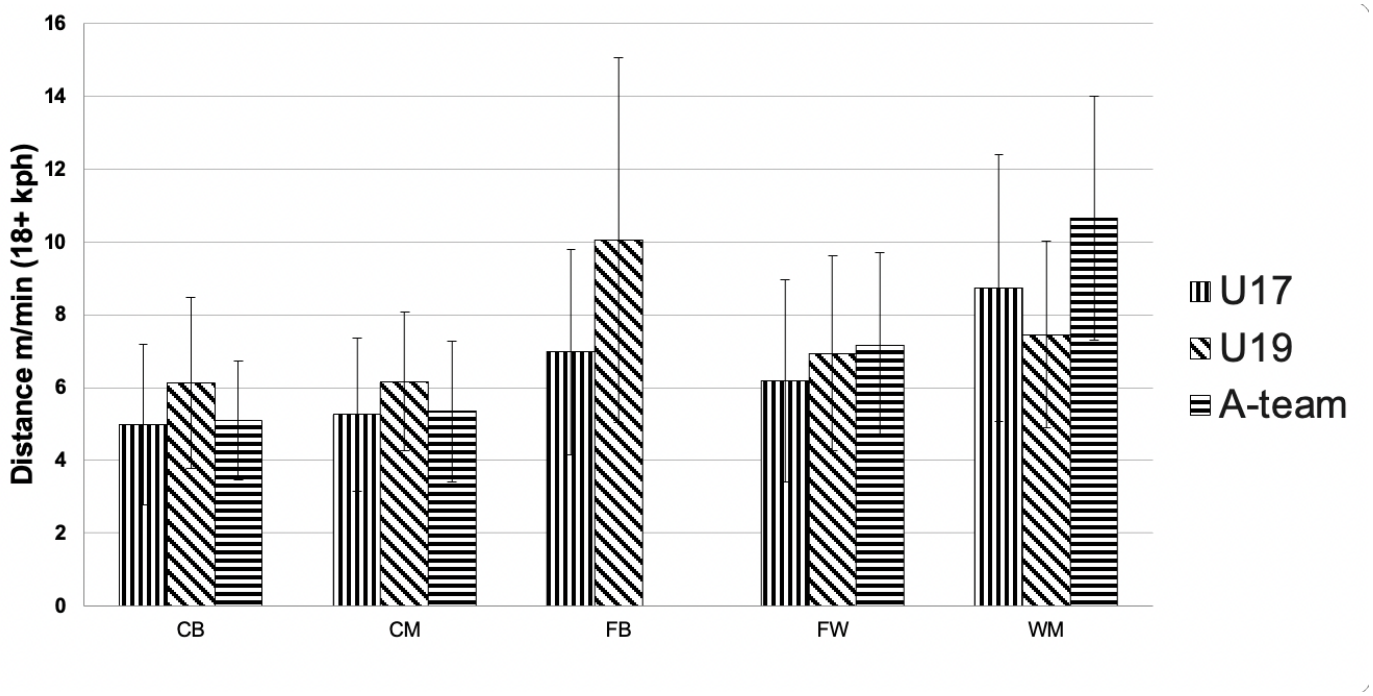

Figure 41. *Mean distance covered per minute at a speed above 18 kph between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

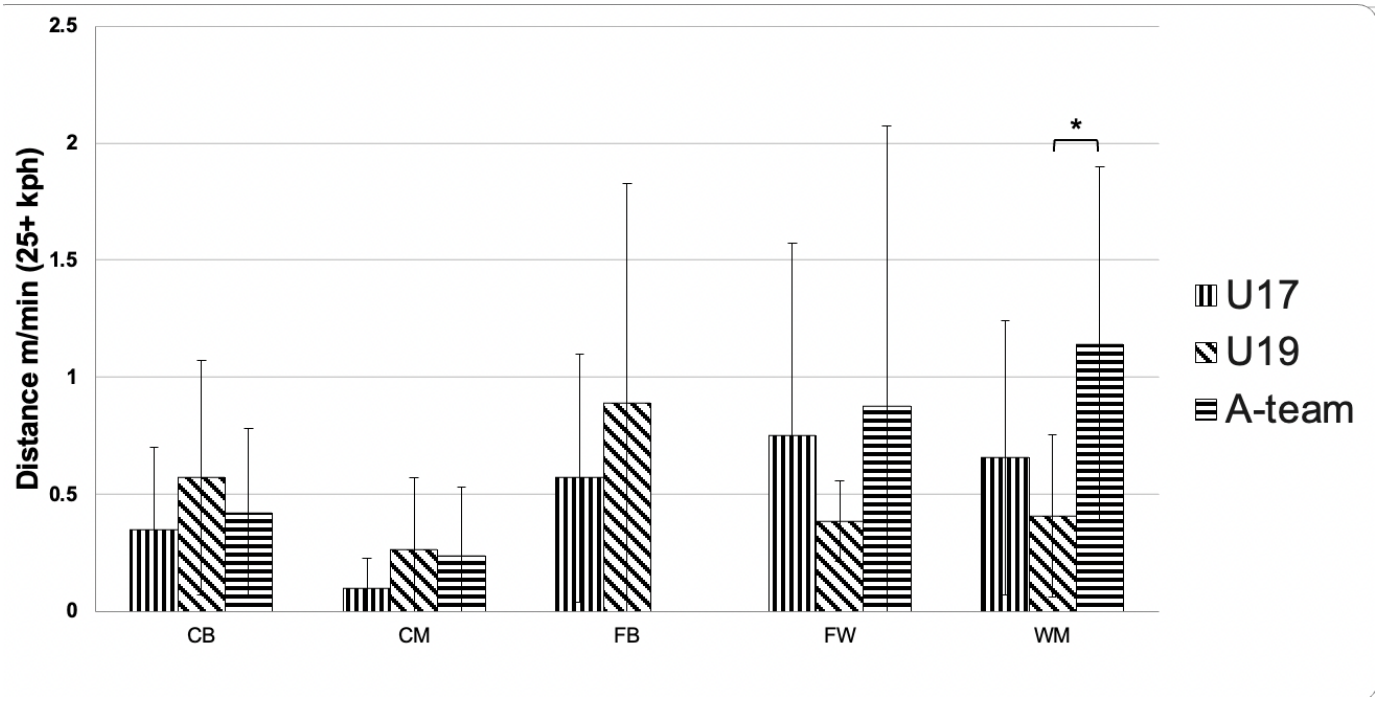

Figure 42. *Mean distance covered per minute at a speed above 25 kph between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

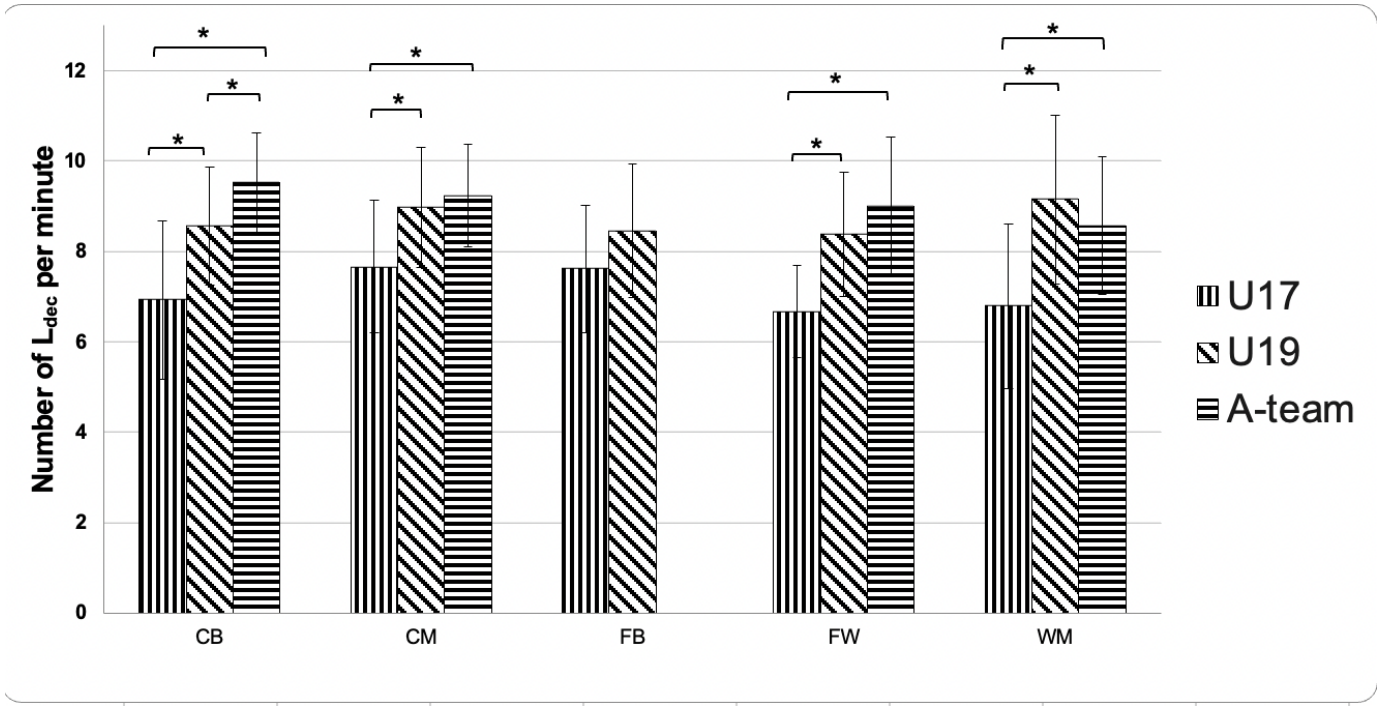

Figure 43. *Mean number of low deceleration between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

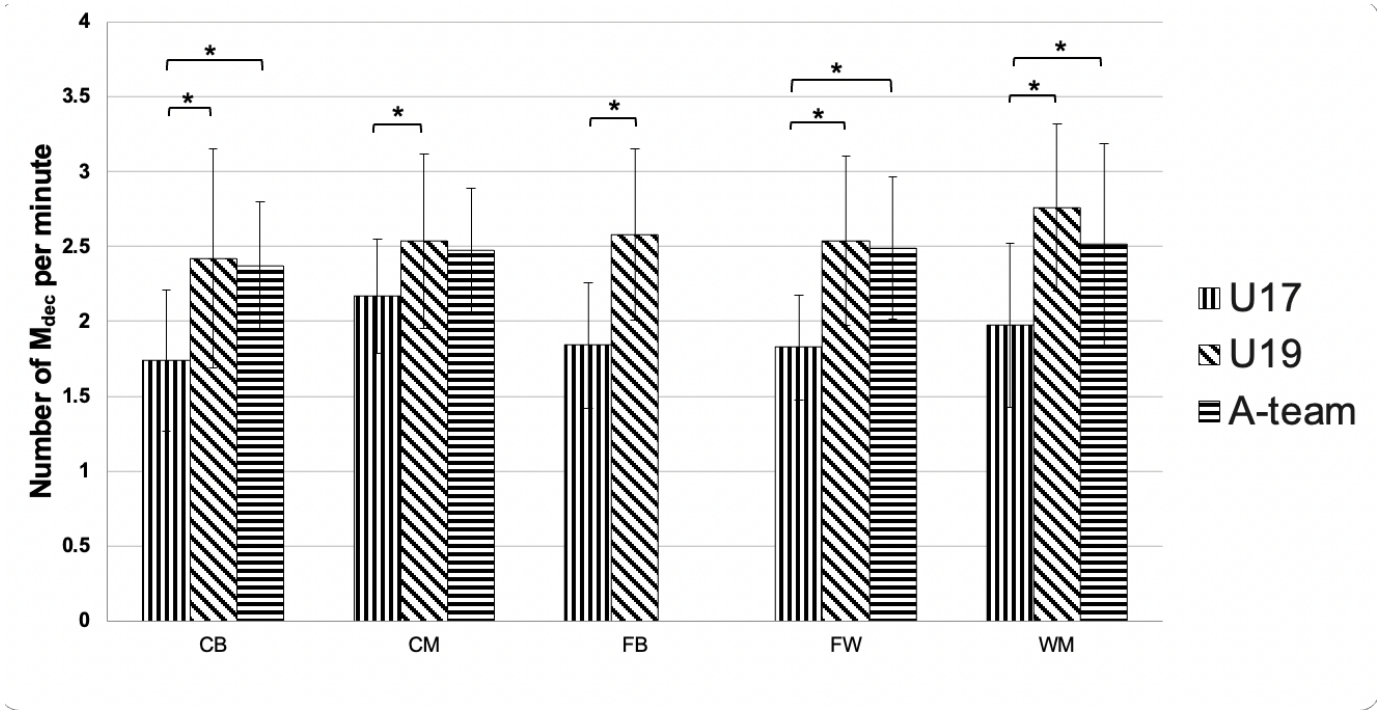

Figure 44. *Mean number of moderate deceleration between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

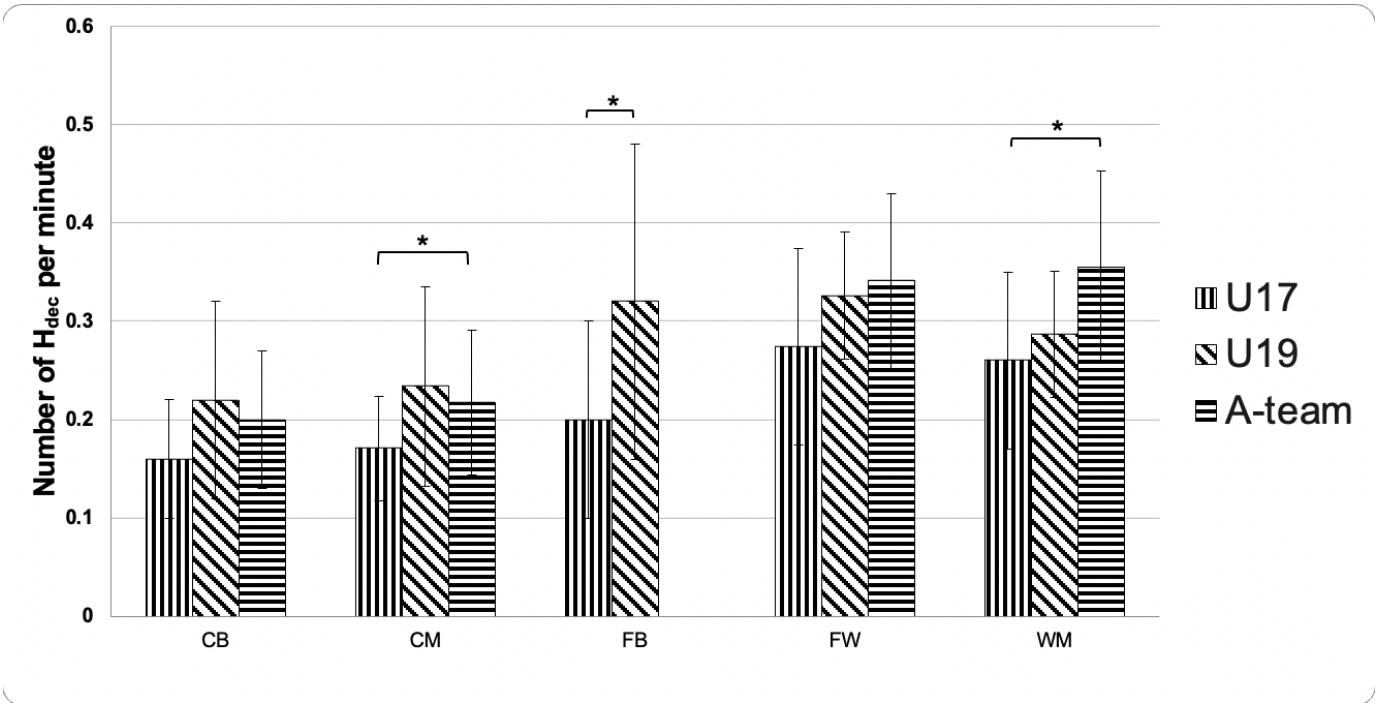

Figure 45. *Mean number of high deceleration between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

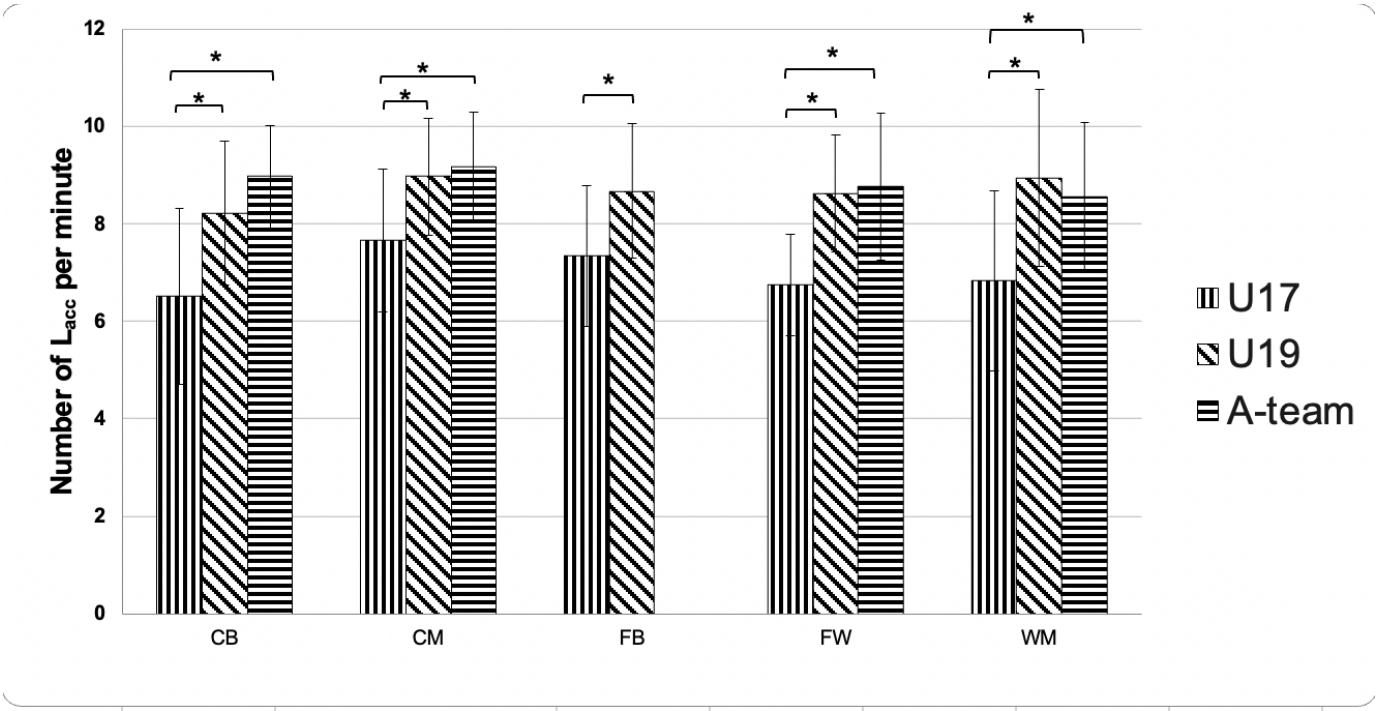

Figure 46. *Mean number of low accelerations between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

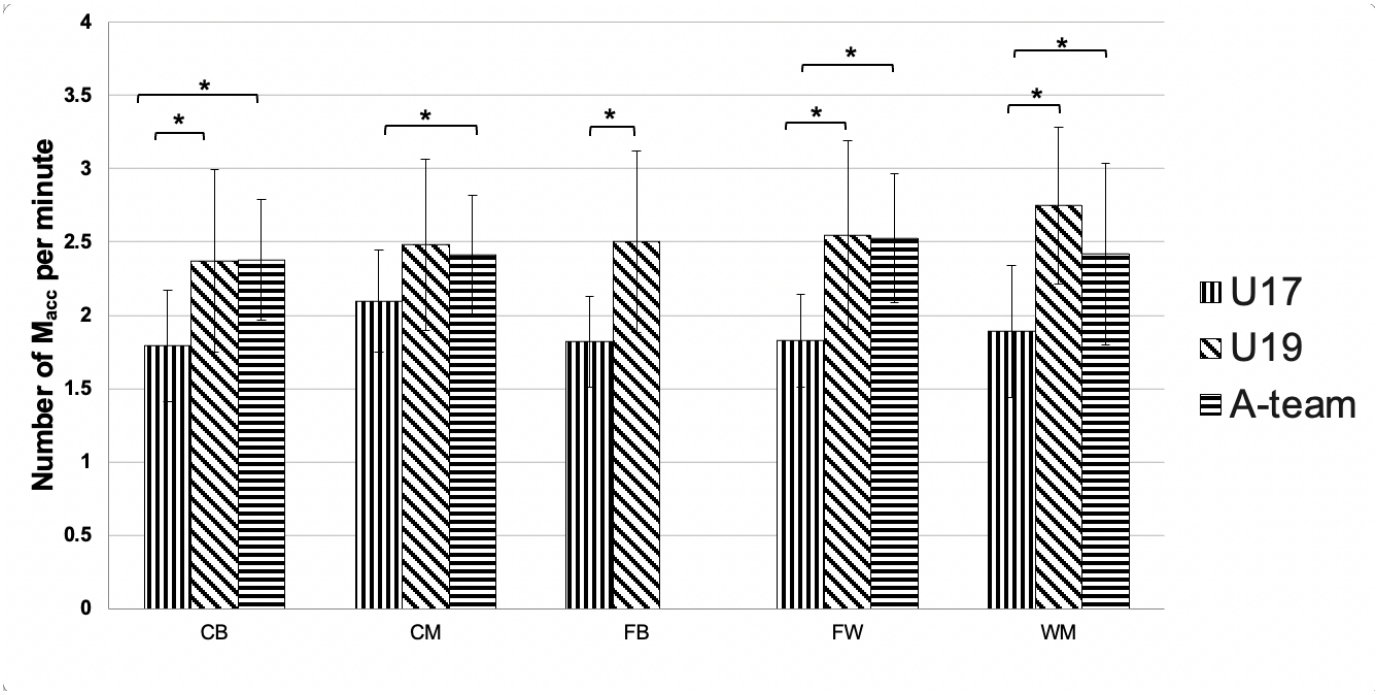

Figure 47. *Mean number of moderate accelerations between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

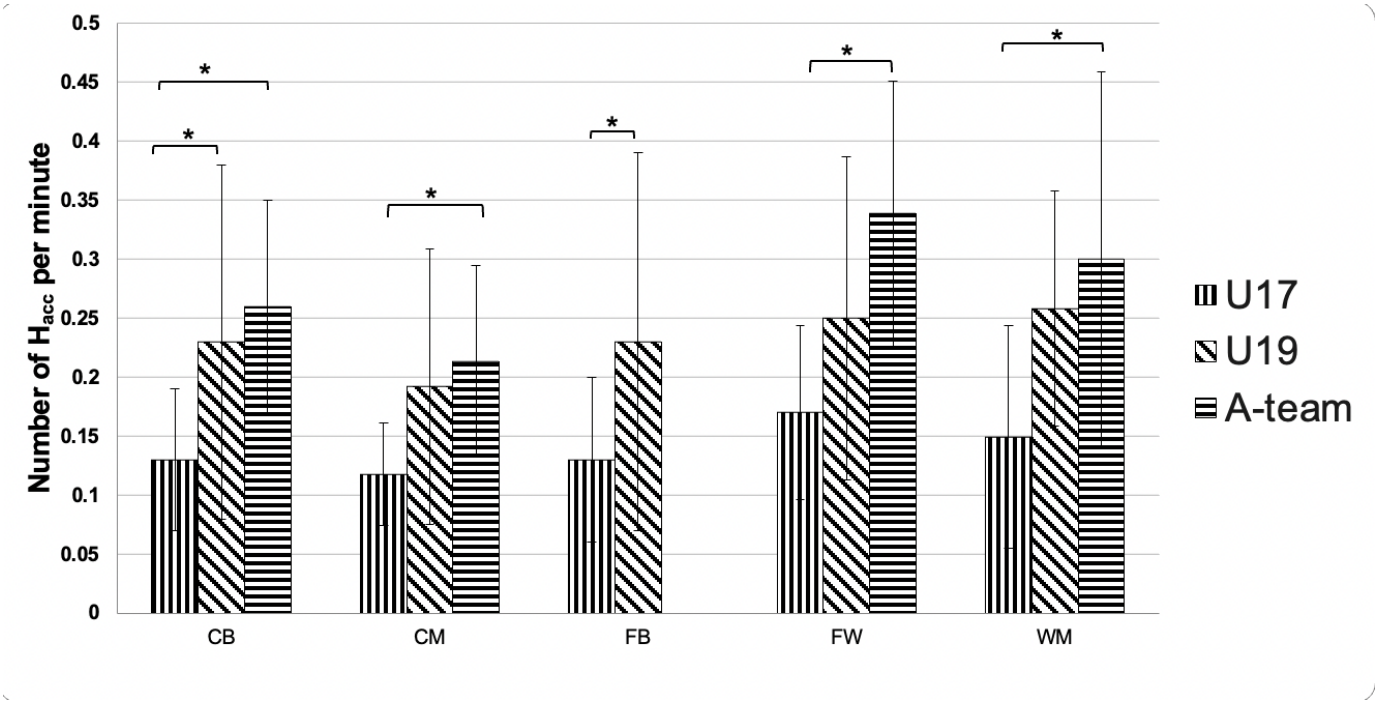

Figure 48. *Mean number of high accelerations between each playing position at U17, U19 and the A-team during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

Comparison of playing positions within the team

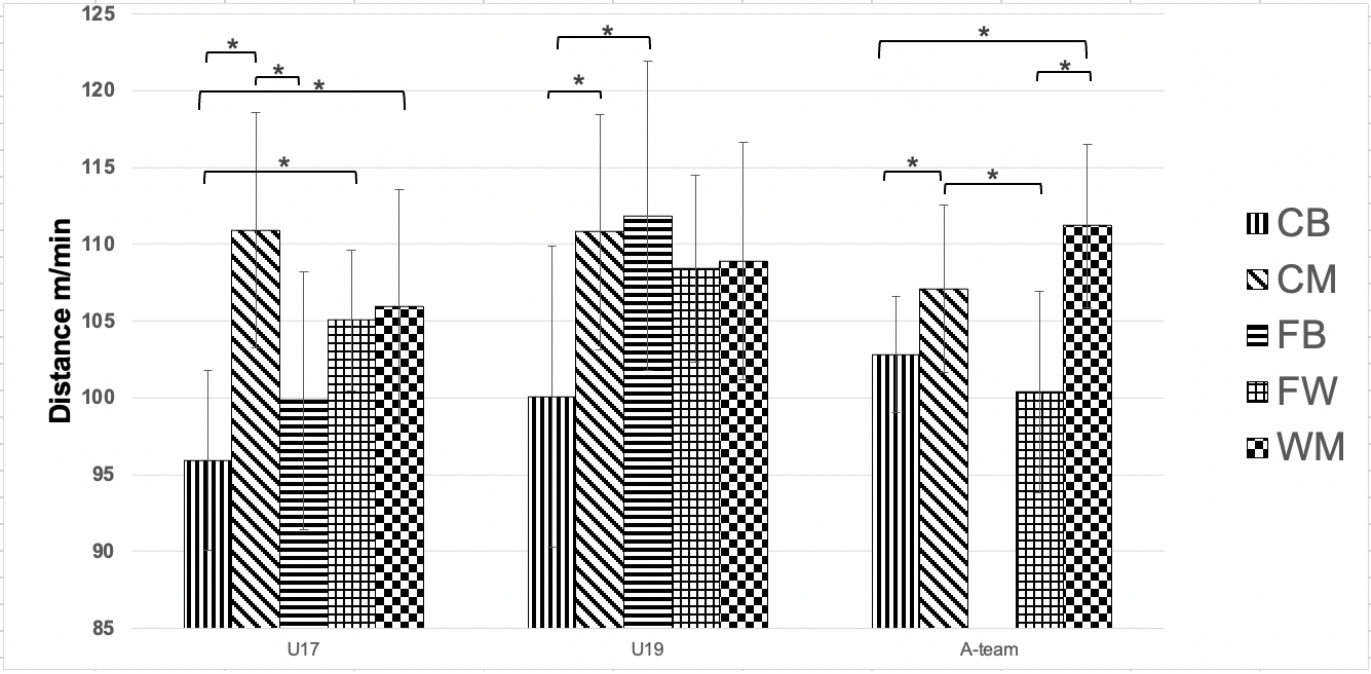

Figure 49. *Mean distance covered per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

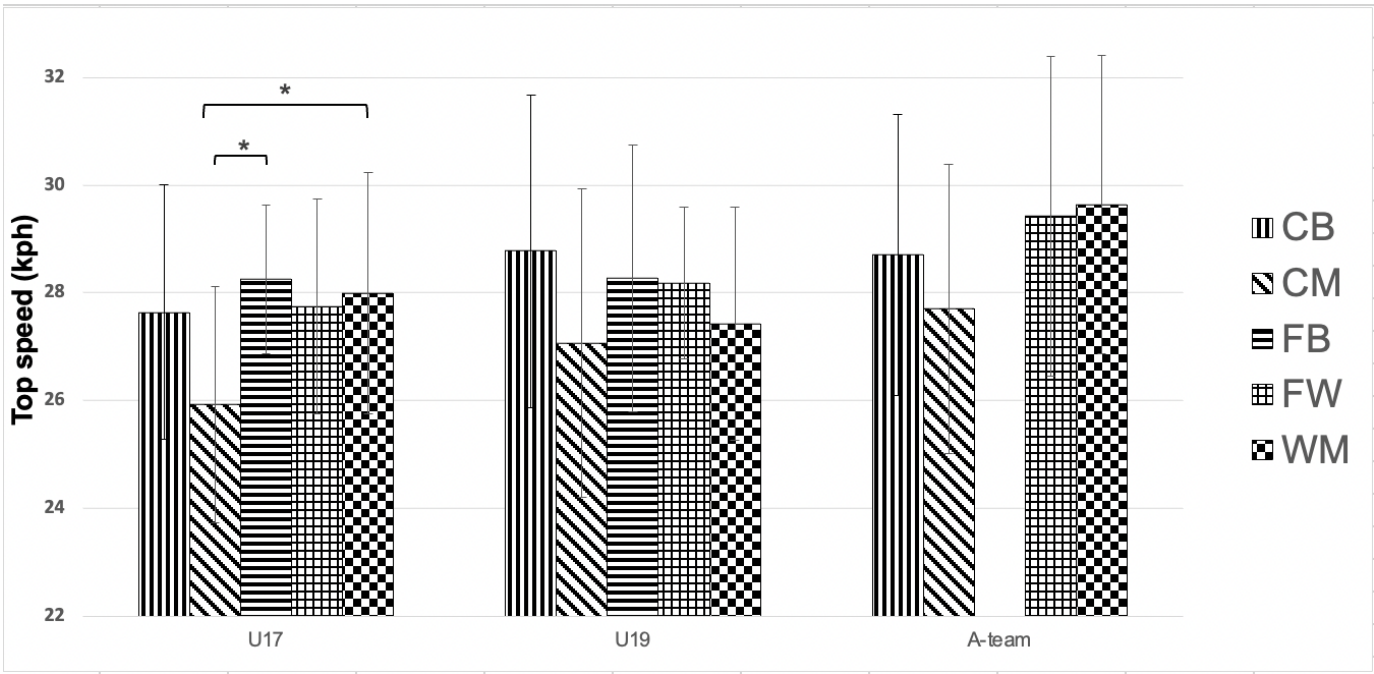

Figure 50. *Top speed of each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

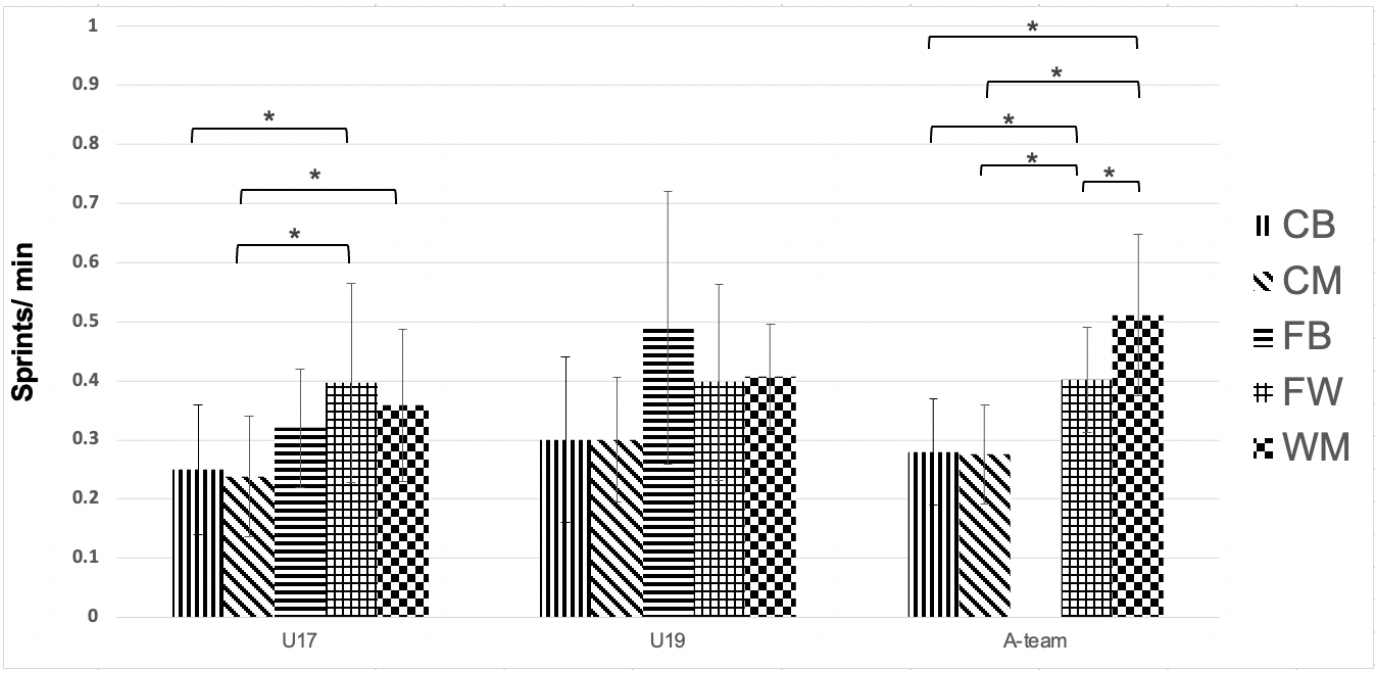

Figure 51. *Number of sprints per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

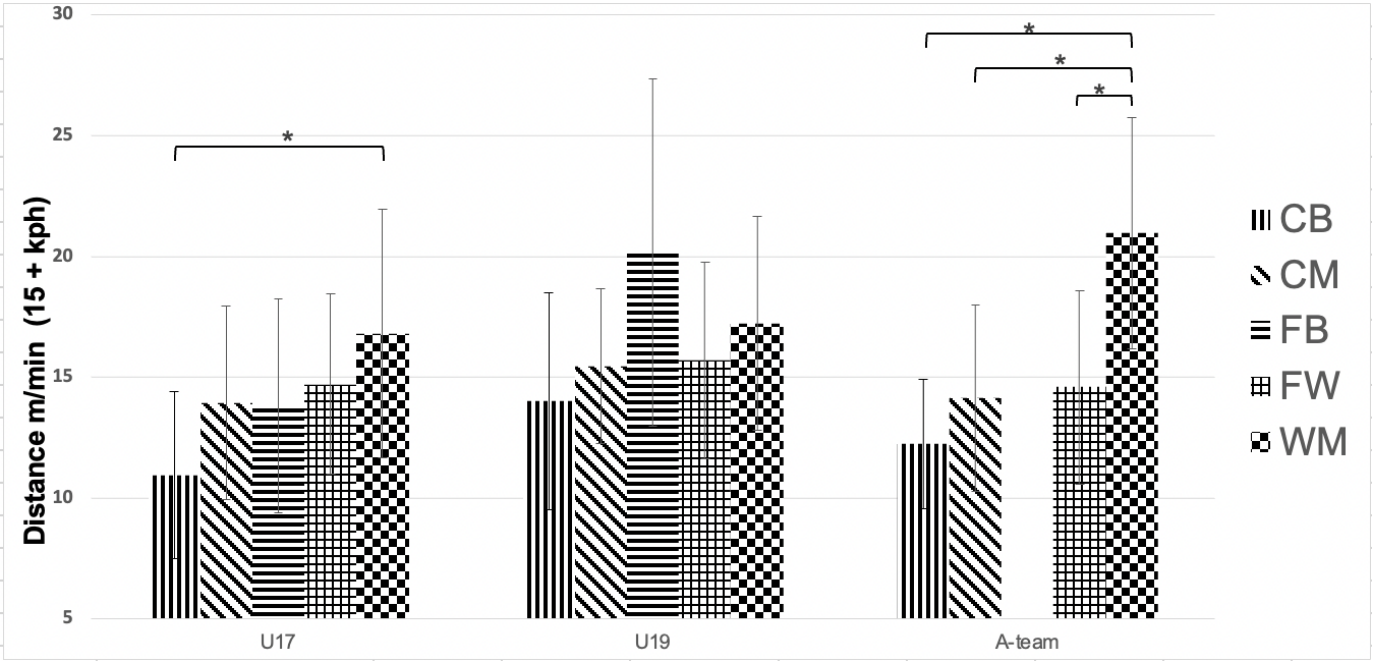

Figure 52. *Distance covered per minute at a speed above 15 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

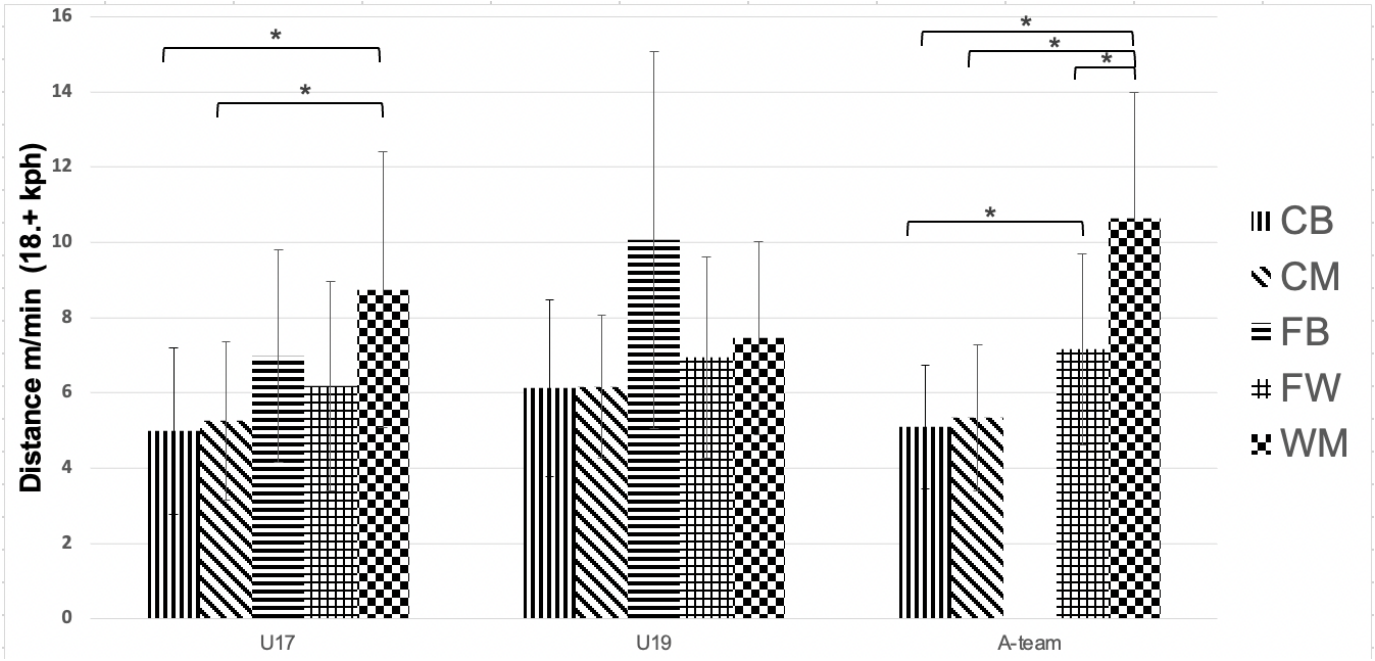

Figure 53. *Distance covered per minute at a speed above 18 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

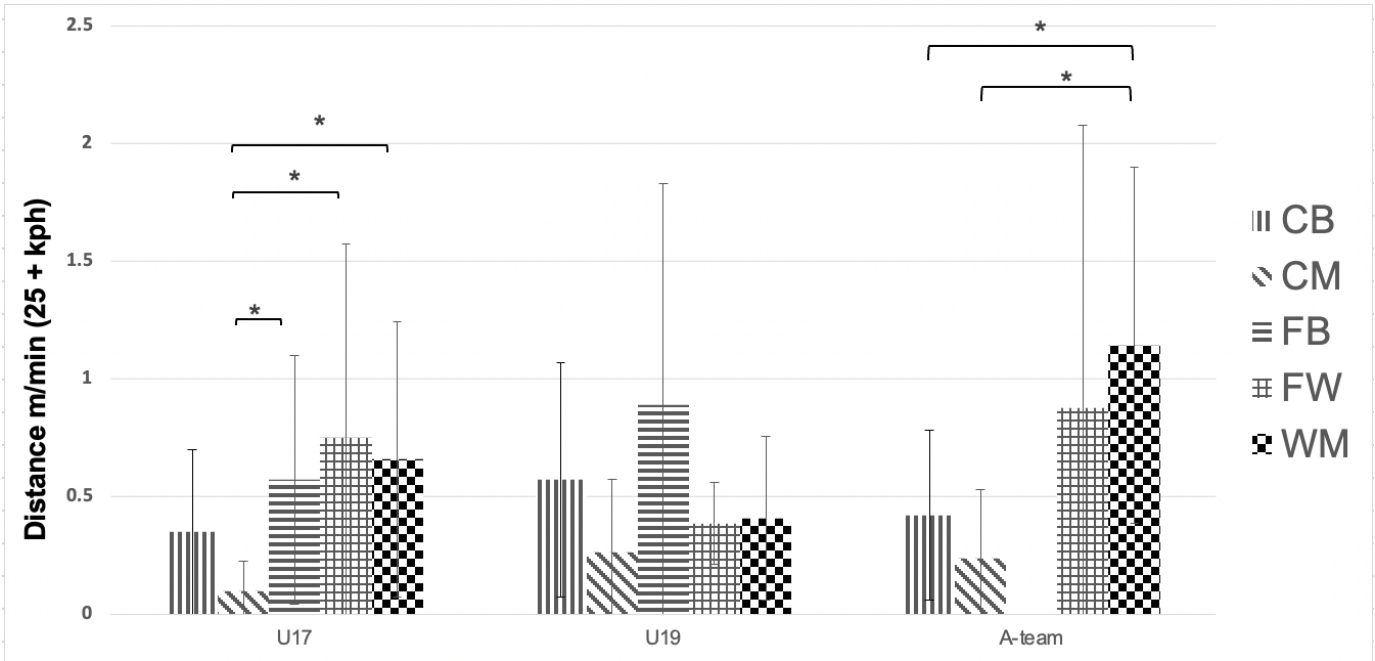

Figure 54. *Distance covered per minute at a speed above 25 kph by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

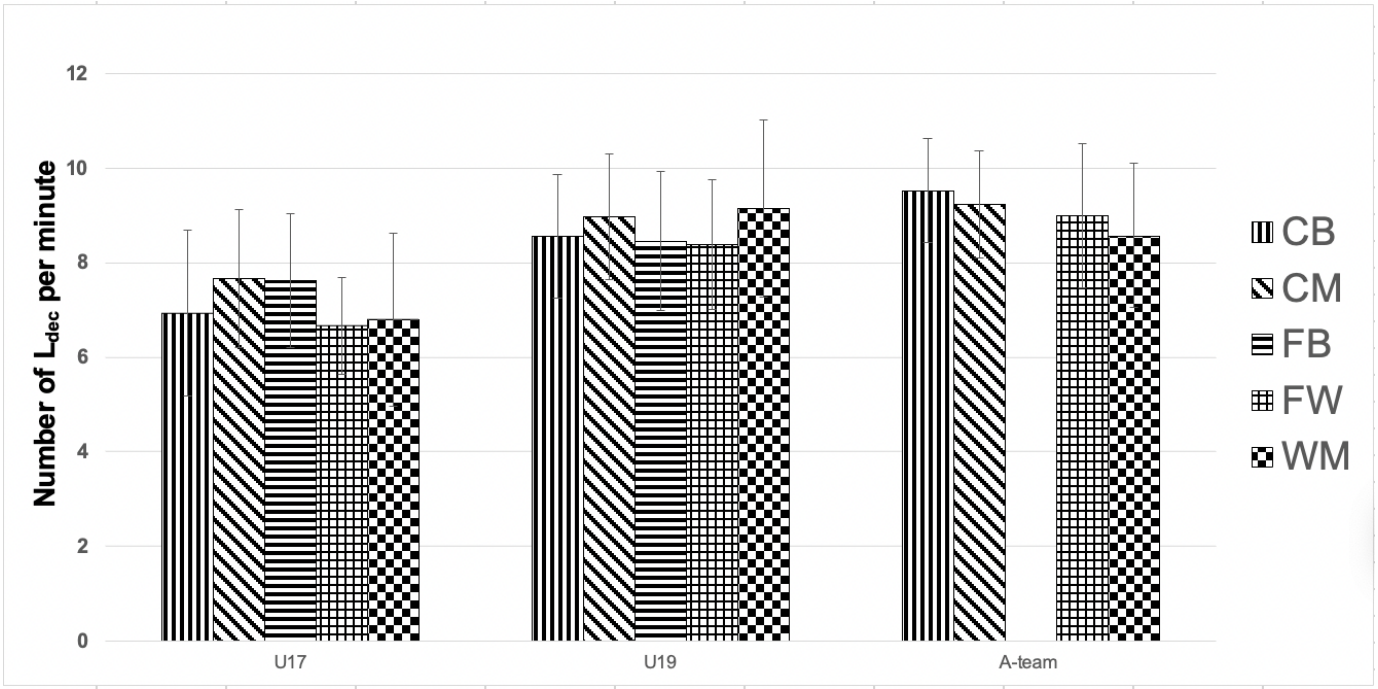

Figure 55. *Number of low decelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

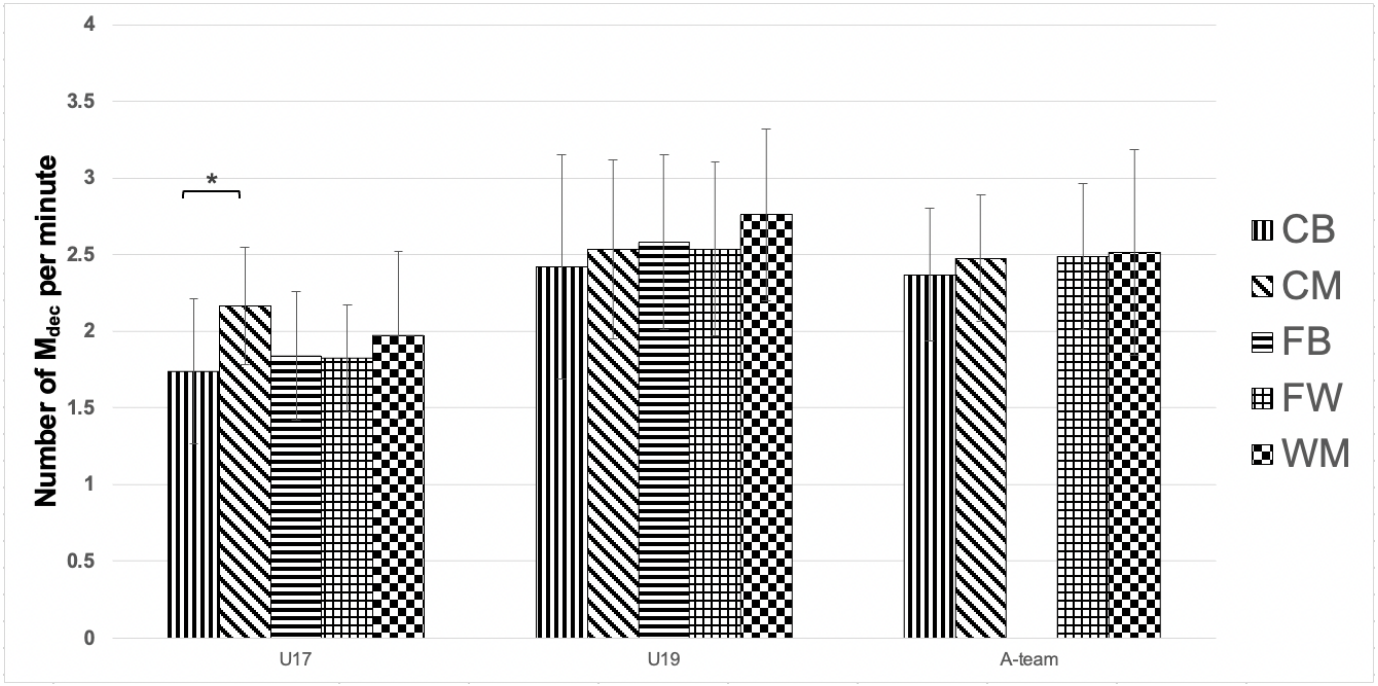

Figure 56. *Number of moderate decelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

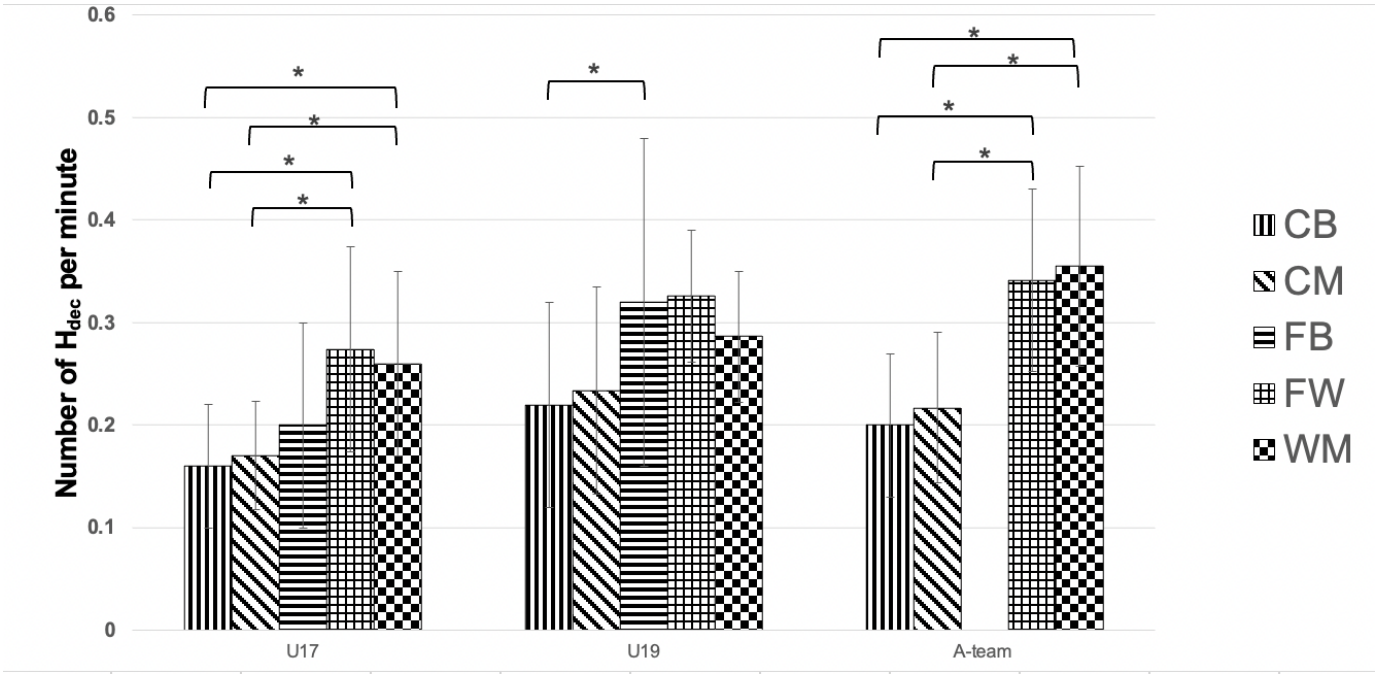

Figure 57. *Number of high decelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

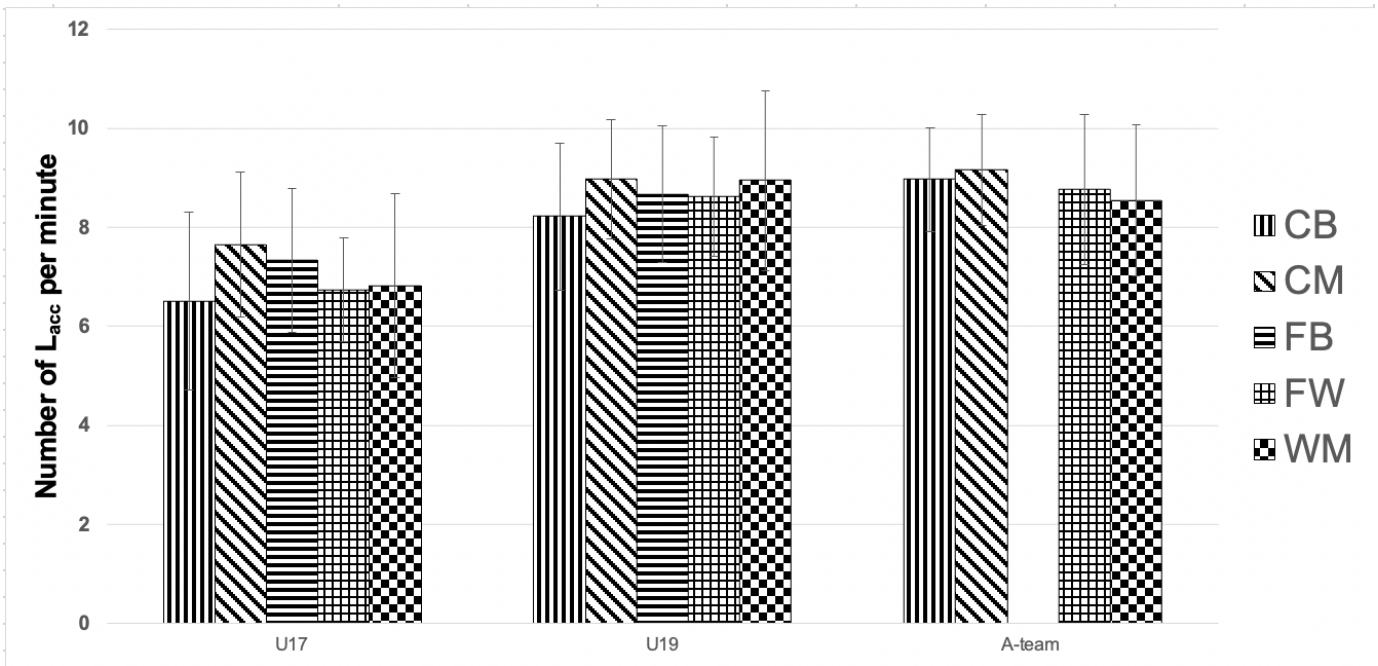

Figure 58. *Number of low accelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

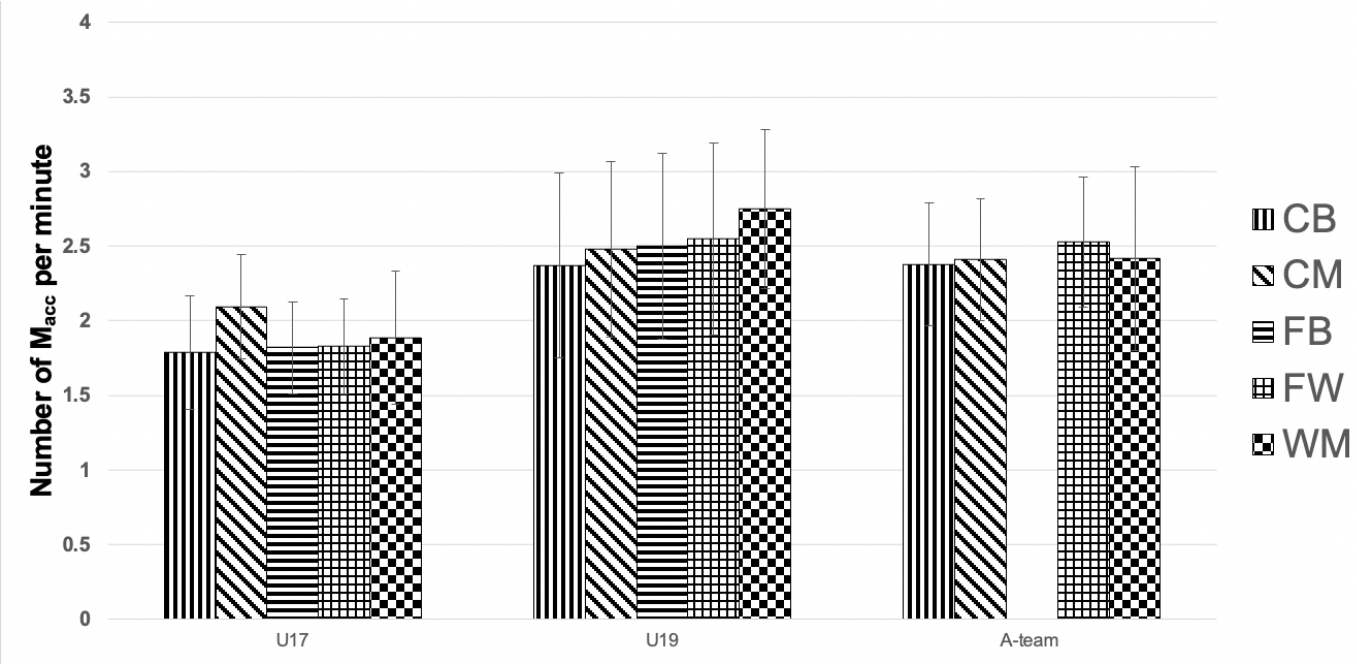

Figure 59. *Number of moderate accelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$

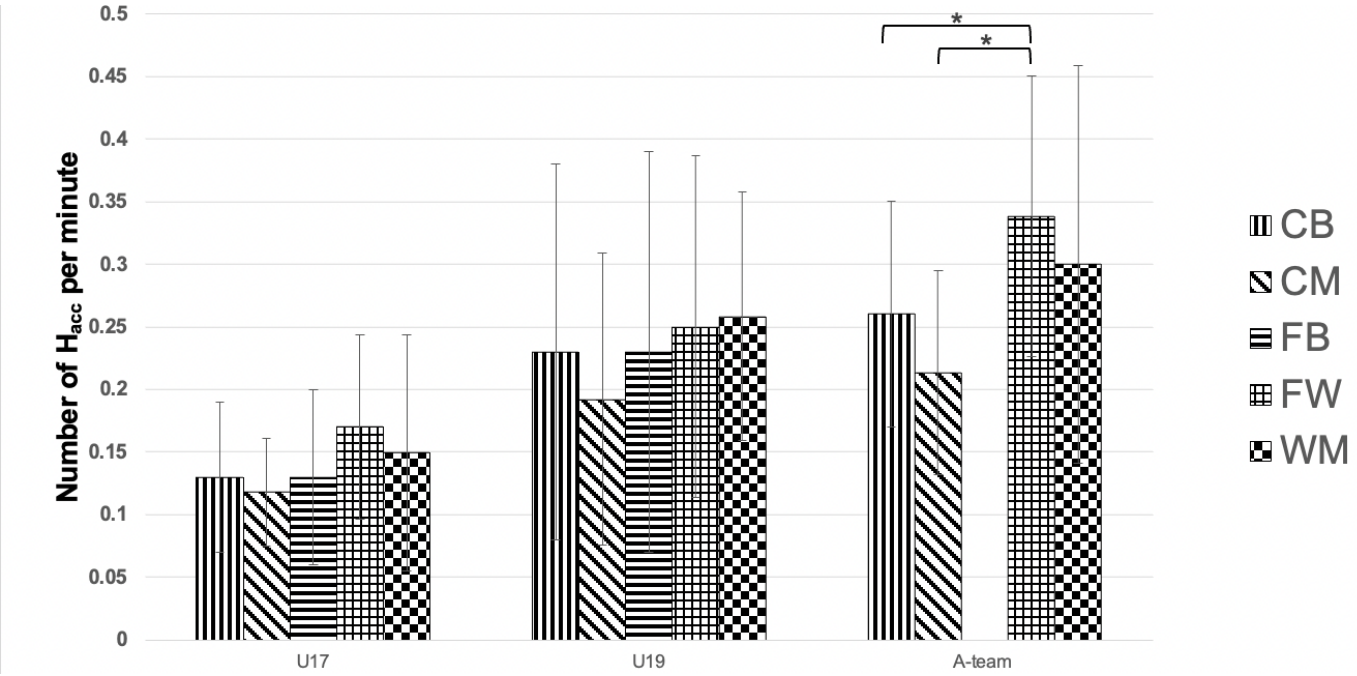

Figure 60. *Number of high accelerations per minute by each playing position (CB, CM, FB, WM and FW) during competitive international matches. Patterned bars are means. Error bars illustrate SD.* $* = p < .05$