Original Article

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External and Internal Load of International Matches According to Age Categories and Positions: A Case of Women's National Team

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Abstract: *Objective*: To evaluate and compare the external and internal load of international matches between age categories and playing positions in a women's national team. *Methods:* 40 players from 3 age categories of the Chilean national teams. 14 players belonged to the U-17, 14 to the U-20 and 12 to the Senior National Team. The players were categorized according to the following playing positions: full-back (FB), central defender (CD), midfielders (MF), wide attacker (WA) and Striker (ST). The following variables were recorded: total distance (TD); distance in high-speed running >18 km/h (HSR); number of sprints at >18 km/h (NS); maximum velocity (MV), player load (PL) and rate of perceived effort (RPE). All variables were normalized by time except MV. An ANOVA two way was performed to make the comparison. *Results:* Medium differences were found in NS ($p<0.01$ and $\eta^2p=0.10$) and large differences in MV ($p<0.01$ and $\eta^2p=0.17$) and in RPE ($p<0.01$ and $\eta^2p=0.19$). There were large interaction effects ($p<0.05$ and $\eta^2p>0.15$) in TD, HSR, PL, and MV. There were large differences in all variables of external load according to playing position ($p<0.01$ and $\eta^2p>0.15$). *Conclusion:* There are differences in external load based on age categories, playing positions and the interaction between both factors. The results can help coaching staff to program and monitor training microcycles according to the factors analyzed.

Keywords: young, match running performance, female, soccer

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INTRODUCTION

Women's football has experienced remarkable growth, with a significant increase in the number of players in international competitions and professional leagues [1]. This boom has raised performance expectations, which calls for specialized scientific research to optimize the performance of female players [2]. However, recent reviews emphasize that despite the increase in participation, scientific literature focused on performance monitoring in women’s football is still scarce and requires urgent expansion [3].

To accurately assess the loads to which players are subjected and the psychophysiological response to such effort, known as external load and internal load, respectively [4,5], a clear operational distinction of both concepts is essential to ensure consistency in monitoring and comparison across studies [6]. In relation to external load, is quantified how running actions in and are categorized according to the velocity of movements, which can be directly measured using global positioning systems [7]. It has been shown that high intensity actions such as accelerations, decelerations, and sprints are positively related to sports performance indicators in men's football [8]. Another indicator of external load is the player load, which quantifies the acceleration and deceleration triaxially during the competition, which can reflect other types of actions, such as jumps, changes of direction and tackles [9]. Nonetheless, most of these findings derive from male populations, which limits their direct applicability to female football, particularly at the developmental level [3].

While it is important to understand the external load to which players are subjected, it is crucial to analyze in parallel the internal load produced, a practical and accessible tool is the session rate of perceived effort (RPEs), which allows monitoring and prescribing training loads [10,11]. The use of RPE in female football has been validated as a sensitive indicator for internal load, especially when compared to physiological measures like heart rate and lactate thresholds [12]. Despite the relevance of these indicators, there is still a lack of knowledge about these indicators in women's football, which is even greater in youth categories [13]. This gap is particularly pronounced in elite youth female football, where systematic load profiles are rarely published [14].

Another important factor to consider is the biological maturation stage of female football players, which implies variations in their physical and anthropometric attributes, which may influence the nature and intensity of physical requirements during competition [15]. Therefore, it becomes a priority to evaluate how the internal and external load varies between age categories, with the objective of understanding the physical requirements throughout the sport development of female football players [16]. A recent study by Kobal et al [12] compared the external and internal loading of youth and professional players in a Brazilian female football league, finding large differences in sprint distances (>18 km/hr), small to moderate differences in maximal running speed and higher RPEs in professional football players. However, due to the multifactorial nature of football, a deeper understanding of how internal and external loading variables interact with other tactical factors, such as playing position, is required [17]. This reinforces the need to examine contextual variables—such as match demands by position or age—that could condition training adaptation and recovery strategies [18]. Therefore, the present study seeks to fill this gap by providing a comparative analysis of internal and external loads between youth and adult players in elite-level women’s football.

This research aims to evaluate and compare the differences in the external and internal load between youth and adult players on national women's football during official matches considering factors age category, playing position, and the interaction between these factors. The results of the study could provide valuable insights for tailoring training loads based on player’s age and tactical role, enabling accurate monitoring of their progress and allowing them to ensure optimal sport development. Furthermore, analyzing these variables in a high-performance context will contribute to a more detailed understanding of the physical demands of women's football, enabling more efficient planning grounded on scientific evidence. We hypothesize that adult players will present higher external and internal load values compared to youth players, with positional differences influencing the magnitude of these demands. The following research questions guide the study: How do internal and external loads differ between age categories in female football and how do playing positions modulate these loads ?

MATERIAL AND METHODS

Participants

The study involved 40 players from three categories of the Chilean national teams (Table 1). Of these, 14 belonged to the U-17 category, 14 to the U-20 and 12 to the Adult National Team (Senior). The players were categorized according to the following playing positions: full-back (FB), central defender (CD), midfielders (MF), wide attackers (WA) and striker (ST).

Ethical considerations

This intervention did not modify the usual football training nor did it involve motor actions other than those carried out in regular training or the practice of matches. The data analyzed come from routine evaluations carried out on the Chilean national football teams. The Chilean Football Federation authorized the use of the athletes' test results for publication. All participants signed an informed consent before the start of data collection and were free to withdraw from the study at any time. In the case of players under 18 years of age, the signed consent of their parents or guardians was obtained. Before the start of the season, all players underwent a full medical examination. The study was carried out following the principles of the Declaration of Helsinki [19] and was approved by the Institutional Ethics Committee of Virgen Macarena and Virgen del Rocío University Hospitals in Seville, Spain (C.P. RENFUTCHILE—C.I. 2355-N20, June 28, 2021).

Procedures

This quantitative study had a non-experimental cross-sectional design with a descriptive scope. For this study, the players were selected by the coach of each category and represented Chile in official competitions. Data was collected from three international tournaments (U-17, U-20 and Adult National Team), considering exclusively field players, goalkeepers were excluded from the analysis (Figure 1). The U-17 National Team participated in the 2022 U-17 South American Tournament, held in Uruguay, playing seven matches: Group stage: vs. Uruguay, Colombia, Peru and Ecuador. Final phase: vs. Brazil, Colombia and Paraguay. The U-20 National Team competed in the 2022 South American U-20 Tournament, held in Chile, playing four matches in the group stage: vs. Argentina, Peru, Venezuela and Colombia. For its part, the Adult National Team played the 2019 World Cup in France, facing Sweden, the United States and Thailand in the group stage. At the time of the evaluation, the Chilean National Team was ranked 36th in the FIFA ranking. During the tournaments, the U-17 and U-20 teams played a match every other day, while the Adult National Team competed every four days. Players were

Table 1. Characterization of the players by age category.

Age category	n	Age (years) Mean ± SD	Corporal mass (kg) Mean ± SD	Height (m) Mean ± SD
U-17	14	16.3 ± 0.3	58.5 ± 7.3	1.61 ± 6.3
U-20	14	18.6 ± 0.5	57.5 ± 8.0	1.62 ± 6.9
Senior	12	30.1 ± 3.4	60.5 ± 4.1	1.63 ± 6.1

n – number, SD - standard deviation

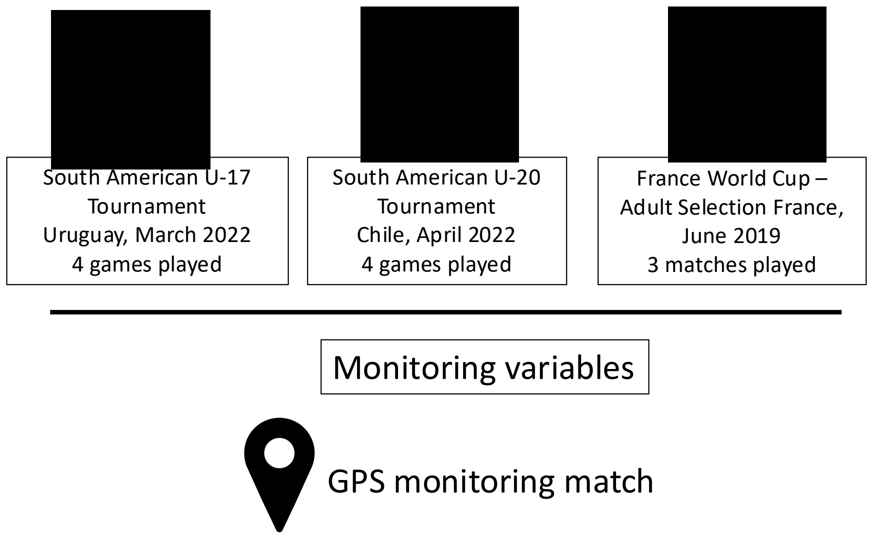

Figure 1. Collection and analysis process of data in official U17, U20, and Senior matches.

excluded from the study if: i) They did not complete a match in its entirety and if ii) They suffered an injury or presented health problems, certified by the team's medical staff. On match days, all players underwent a standardized warm-up, led by the physical trainer of each category. This lasted 20 to 25 minutes and included joint mobility exercises, control and passing, small side games and defensive and offensive blocking work.

External Load

The external charge was collected through 10 Hz GPS devices (Optimeye S5, Catapult Sports, Melbourne, Australia), which were placed in a neoprene harness between the scapulae. The following variables were recorded: total distance (TD); distance in high-speed running >18 km/h (HSR); number of sprints at >18 km/h (NS); maximum velocity (MV) and player charge (LP). The PL is an instantaneous variable of acceleration deltas divided by a scale factor and is for quantifying other demanding activities, such as impacts, jumps, and changes in direction. All variables were normalized by minutes of play.

Internal Load

In order to quantify the internal load, the rate of perception effort scale (RPE) was used, where each player rated the intensity of the match using a scale of 0-10 in a Cloud-based spreadsheet (Google Drive, Google, CA, USA) 30 minutes after the matches [20]. No partners were present when responding to avoid response bias [21]. Subsequently, the RPE session (RPEs) was obtained, which is the product between the RPE and the duration (minutes) of the activity (match) [22].

Statistical analysis

The normality of the data was analyzed through the Kolmogorov-Smirnov test, assuming a normal distribution ($p>0.05$). External load results are presented using descriptive mean and standard deviation statistics. To analyze the difference between age categories and playing positions and interaction between factors, ANOVA two-way test was performed and effect sizes were calculated as partial eta squared (η^2p). The effect size categorization was: trivial $\eta^2p \leq 0.01$; small $0.01 < \eta^2p \leq 0.06$; medium $0.061 < \eta^2p \leq 0.14$ and large $\eta^2p > 0.14$ [23]. In addition, Tukey's post-hoc was applied to correct for significance and identify differences between groups. In the case of post-hoc tests of the interaction effect (age category and positions), only differences between positions in the same category and/or between the same position between categories were reported. All statistics were carried out through JASP software (version 0.19.1.0). An alpha of 0.05 was established. Figure 1 was made in Matlab (version r2023b). Additionally, for practical terms, the game minute data will be described for the factors (age categories and positions).

RESULTS

Table 2 contains the descriptive and inferential statistics by age categories and inferential statistics of the interaction effect. Medium differences were found in PL ($p<0.01$ and $\eta^2p=0.10$), where U-17 had differences with U-20 and Senior and large differences in MV ($p<0.01$ and $\eta^2p=0.17$), where U-20 had differences with U-17 and Senior, and in RPEs ($\eta^2p=0.19$), where Senior had differences with U-17 and U-20. There were large interaction effects ($p<0.05$ and $\eta^2p>0.15$) in TD, HSR, PL, and MV. The post-hoc differences of the interaction effect are in Figure 2.

Table 2. Descriptive and inferential statistics according age categories and interaction effect

Variables	U-17		U-20		Senior		Age category		Interaction	
	M	±SD	M	±SD	M	±SD	p	η^2p	p	η^2p
TD (m/min)	110	9.11	109	6.76	110	10.5	0.55	0.01	<0.01	0.22
HSR (m/min)	5.93	2.07	5.97	2.26	6.14	2.25	0.55	0.01	**0.02**	**0.16**
NS (count/min)	0.43	0.16	0.45	0.16	0.45	0.15	0.51	0.01	0.24	0.09
PL (AU/min)	10.2[a,b]	1.56	11.0	1.50	11.1	1.89	**<0.01**	**0.10**	**<0.01**	**0.22**
MV (km/h)	25.6[a]	1.28	26.9[b]	1.58	26.0	1.91	**<0.01**	**0.17**	**<0.01**	**0.23**
RPEs (AU)	751[a,b]	94.0	696[b]	120	832	80.6	**<0.01**	**0.19**	0.22	0.09
MP (min)	89.1	2.57	89.0	2.76	89.3	2.65	-	-	-	-

a difference with U-20; b difference with Senior; M mean; SD standard deviation; TD total distance; HSR high speed running >18 km/h; NS number of sprints; PL player load; MV maximum velocity; RPE rate of perceived effort; MP minutes played; η^2p partial eta squared; AU arbitrary unit.

Table 3. Descriptive and inferential statistics according positions

Variables	Full back		Central Defender		Midfielder		Wide attacker		Striker		Position	
	M	±SD	M	±SD	M	±SD	M	±SD	M	±SD	p	η^2p
TD (m/min)	112[a]	8.00	103[b]	6,3	116[c,d]	6,5	113	10	104	6.83	**<0.01**	**0.33**
HSR (m/min)	6.80[a]	2.15	4.97[c]	1.56	5.11[c]	1.89	7.76[d]	1.85	5.74	2.12	**<0.01**	**0.22**
NS (count/min)	0.48	0.18	0.38[c]	0.10	0.39[c]	0.13	0.56	0.14	0.44	0.15	**<0.01**	**0.17**
PL (AU/min)	10.6[a,b]	1.42	9.55[b]	1.20	12.1[c,d]	1.68	10.6	1.56	10.1	1.14	**<0.01**	**0.42**
MV (km/h)	25.4[a,c]	1.17	26.8[b]	1.09	24.8[c]	1.14	27.2	1.46	27.0	2.74	**<0.01**	**0.32**
RPE (AU)	772	101	751	126	755	95.1	790	96.9	741	161	0.84	0.01
MP (min)	89.0	2.85	89.9	0.57	89.6	1.91	89.3	1.59	85.6	6.23	-	-

a difference with Central defender; b difference with Midfielder; c difference with Wide attacker; d difference with Striker; M mean; SD standard deviation; TD total distance; HSR high speed running >18 km/h; NS number of sprints; PL player load; MV maximum velocity; MP minutes played; η^2p partial eta squared; AU arbitrary unit.

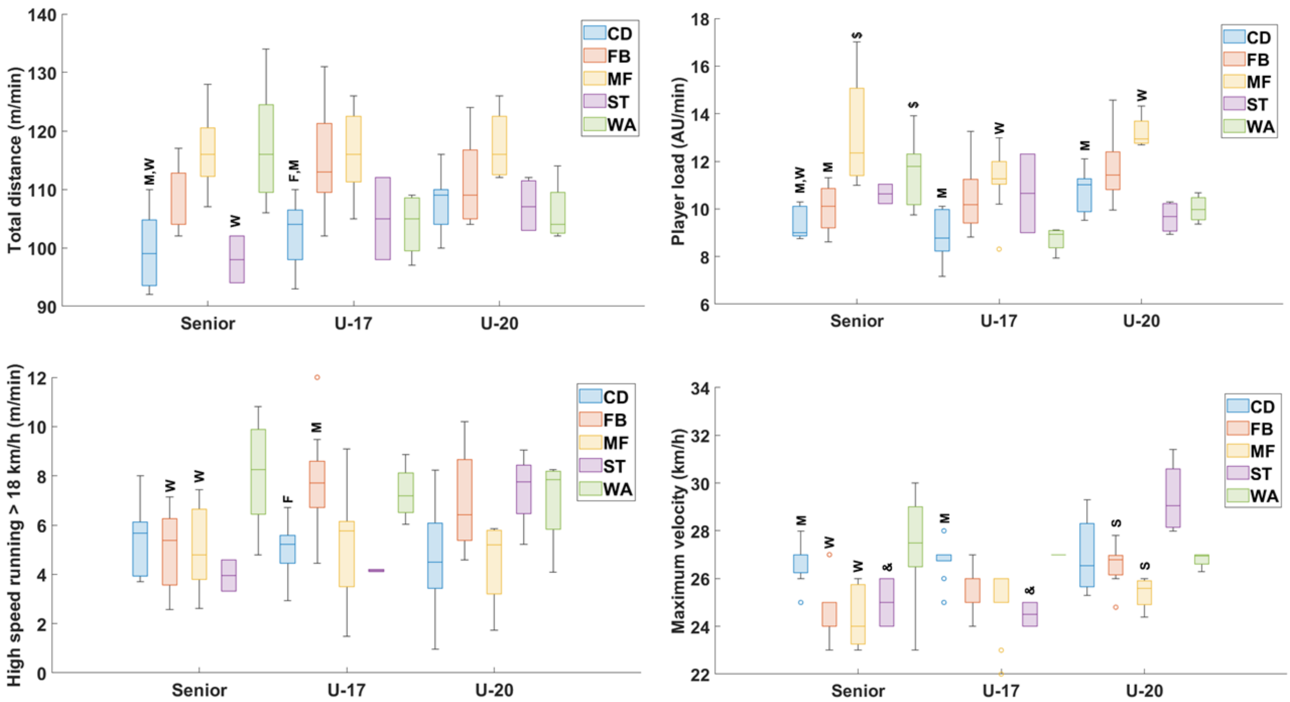

Figure 2. Box plot of total distance, player load, high-speed running and maximum velocity and post-hoc of interaction effects. CD (central defender); F differences with fullback (FB) p<0.05; M differences with midfielders (MF) p<0.05; S differences with striker (ST) p<0.05; W differences with wide attacker (WA) p<0.05; $ difference with U17; & difference with U20.

Table 3 contains the descriptive and inferential statistics by positions. There were large differences in all variables (p<0.01). In TD (η^2p=0.33), CD had a difference with FB and MF and FM with WA and ST. In HSR ((η^2p=0.22), FB differed with CD and WA with CD, MF and ST. In NS (η^2p=0.17), WA had differences with CD and FP. In PL (η^2p=0.42), FB differed with CD and MF and FM with CD, WA and ST. In MV (η^2p=0.32), FB differed with CD and FP, DC with MF and MF with WA and ST.

DISCUSSION

The present study aimed to evaluate and compare the external and internal load between youth and senior players on the national women's football team during official matches. The main findings were: (i) differences for PL, MV and RPEs for age categories; (ii) differences for all external load variables by playing position; (iii) differences for TD, HSR, PL and MV by interaction effect between both factors.

In relation to differences between positions from the three categories, it was observed that CD covered significantly lower TD than FB and MF, while ST also exhibited significantly lower distance compared to MF and WA. These findings align with data reported from the 2023 FIFA women´s World Cup, where both CD and ST exhibited a TD below the average for all positions [24]. Regarding HSR, CD obtained significantly lower values than FB and WA, as also MF compared to WA. These results are consistent with most previous research, which has shown a higher HSR demand in wide-playing positions such as WA and FB [25]. In terms of PL, MF exhibited significantly higher values compared to all other positions, which is consistent with the findings of Panduro et al. [21], who reported that MF performed the highest number of accelerations and decelerations throughout matches of an entire season. Regarding the MV variable, the highest values were obtained by WA, ST, and CD, while MF presented the lowest. These results can be explained by the tactical roles of CD and ST, who frequently perform sprint actions in goal-scoring situations [26].

Regarding positional differences within the same categories, both the Senior and U-17 teams reported differences between positions for the TD, HSR, PL, and MV variables, whereas the U-20 only showed differences in PL and MV. In this regard, most studies conducted with Senior players have reported significant differences between positions [27]. However, the limited research available on young female footballers has yielded different results [28,29]. In the study by Ramos et al. [24], conducted with players from the Brazilian U-20 national team, significant differences were observed between CD and the rest of the positions across all analyzed variables, including TD, HSR, and PL, while the FB players reported the highest values across all metrics. Conversely, in the recently published study by Myhill et al. [25], no statistically significant differences were found between any playing positions. Regarding the Senior category, the present study indicates that CD covered the lowest TD, a result that aligns with the findings of Bradley [19] based on data from the 2023 FIFA Women's World Cup. Meanwhile, WA covered the greatest distance in HSR, which is consistent with existing literature demonstrating that wide attacking players achieve the highest values in this variable [27]. Additionally, MF recorded the highest PL and TD values, as also shows Bradley [19] in his previously mentioned findings. This marked differentiation observed in Senior teams may be attributed to greater tactical organization at these categories, leading to a higher degree of physical demand specialization among playing positions.

Significant differences were found in PL between Senior and U-17 MF and WA, while in MV, Senior ST and U-17 ST showed significant differences compared to U-20 ST. These results differ from those reported by Ramos et al. [24], who observed significant differences favoring Senior players in all playing positions for TD, PL, and HSR compared to U-17 players, as well as for most positions in the U-20 category. One explanation for the inter-category differences found in the present study could be the variation in the level of opposition faced by Senior players compared to those in the U-17 and U-20 categories [30,31]. Facing higher-level opponents may require a more structured defensive strategy, potentially resulting in lower physical demands [32].

Regarding the differences in age categories, the results in the literature are controversial. A study conducted in a professional team of Brazilian female football players found differences in HSR, RPEs and MV, and not in TD between age categories [16]. Another study with Brazilian national team found differences in TD, distance >15 km/h and >20 km/h and PL [33] with both studies having senior players higher values. In contrast, our results show that U-20 player have higher values of MV. The main controversies with literature are the differences in HSR and TD, this may be due to methodological factors, such as the normalizing variables by minutes of play and the levels of the teams analyzed.

LIMITATIONS AND FUTURE RESEARCH

This study presents several limitations that should be considered when interpreting the results. First, the sample was relatively small, not randomized, and included players from three different national team categories, which may affect the generalizability of the findings. Second, only eleven official international matches were analyzed, and although they were of highly competitive relevance (South American Championships and FIFA Women's World Cup), the limited number decrease the external validity of results. Third, biological maturation data were not collected, a factor known to influence the physical performance of youth players. Finally, contextual variables such as scoreline, red cards, opposition quality, and tactical systems were not included and may have influenced the physical demands observed. Future studies should address these limitations by incorporating larger and more homogeneous samples, controlling for contextual variables, and including technical-tactical performance indicators.

CONCLUSION

There are differences in external load between age categories and playing positions, with specific variations within each category. These findings are key to the development of sports performance, as they allow the coaching staff to optimize the planning and monitoring of training cycles according to age and playing position. Understanding these differences can contribute to the detection and development of athletes by creating specific performance profiles based on the player's developmental stage and role on the field. This knowledge can support more efficient and personalized progression toward higher competitive levels.

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