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Comparison between Junior and Recreational based on Internal and External Load Response in Soccer

Comparación entre Junior y Recreativo según la carga interna y externa Respuesta en el fútbol

*Andika Bayu Putro, **Awang Firmansyah, *Tommy Apriantono, *Muhamad Fahmi Hasan, **Toho Cholik Mutohir; **Muchamad Arif Al Ardha; **Achmad Widodo, **Rizky Maulana

*Institut Teknologi Bandung (Indonesia), **Universitas Negeri Surabaya (Indonesia)

Abstract. The characteristics of soccer games tend to be at medium and high intensity. Measurement of heart rate response and activity profile can be used to assess the physical condition performance of players in planning the right program. The purpose of this study was to analyze the differences between heart rate response and activity profile in junior and recreational soccer players. The sampling technique used was purposive sampling. 24 male soccer players (12 junior Aged 11.58 ± 0.28 Years, 142.25 ± 8.74 cm, 34.5 ± 6.42 kg) and (12 recreational Aged 32.7 ± 1.38 Years, 170.67 ± 3.92 cm, 73.42 ± 5.33 kg) underwent simulation game sessions of 15 minutes each recorded using Polar Verity Sense and Catapult One to capture internal and external load data. Data were analyzed using the Mann-Whitney U Test to determine the difference between the heart rate of junior and recreational players. The results showed that there was a significant difference between HRavg in junior players (166.1 ± 17.2) and recreation (155.3 ± 10.5) as well as HRmax in junior players (193.1 ± 12.3) and recreation (176.0 ± 10.0) ($p < 0.05$). In addition, in the variable top speed (6.20 ± 0.68) and also maximal acceleration (4.52 ± 0.39) there is a significant difference ($p < 0.05$). This study concludes that there is a significant difference in heart rate response, but in the activity profile only the top speed and maximal acceleration variables between soccer players.

Keywords: heart rate response, activity profile, junior and recreational soccer players

Resumen. Las características de los partidos de fútbol suelen ser de intensidad media y alta. La medición de la respuesta de la frecuencia cardiaca y el perfil de actividad pueden utilizarse para evaluar el rendimiento de la condición física de los jugadores a la hora de planificar el programa adecuado. El objetivo de este estudio fue analizar las diferencias entre la respuesta de la frecuencia cardiaca y el perfil de actividad en jugadores de fútbol juveniles y recreativos. La técnica de muestreo utilizada fue el muestreo intencional. 24 jugadores de fútbol masculino (12 junior Edad 11,58 ± 0,28 Años, 142,25 ± 8,74 cm, 34,5 ± 6,42 kg) y (12 recreativos Edad 32,7 ± 1,38 Años, 170,67 ± 3,92 cm, 73,42 ± 5,33 kg) se sometieron a sesiones de simulación de juego de 15 minutos cada una grabadas utilizando Polar Verity Sense y Catapult One para capturar datos de carga interna y externa. Los datos se analizaron mediante la prueba U de Mann Whitney para determinar la diferencia entre la frecuencia cardiaca de los jugadores junior y los recreativos. Los resultados mostraron que había una diferencia significativa entre la FCavg en los jugadores júnior (166,1 ± 17,2) y los recreativos (155,3 ± 10,5), así como la FCmáx en los júnior (193,1 ± 12,3) y los recreativos (176,0 ± 10,0) ($p < 0,05$). Además, en la variable velocidad máxima (6,20 ± 0,68) y también aceleración máxima (4,52 ± 0,39) existe una diferencia significativa ($p < 0,05$). Este estudio concluye que existe una diferencia significativa en la respuesta de la frecuencia cardiaca, pero en el perfil de actividad sólo en las variables velocidad máxima y aceleración máxima entre los futbolistas.

Palabras clave: respuesta de la frecuencia cardiaca, perfil de actividad, futbolistas juveniles y recreativos

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Muhamad Fahmi Hasan

fahmi.hasan@itb.ac.id

Introduction

Football is the most popular sport and the most important sport universally recognized in the world (Bravo-Sánchez et al., 2017; Capranica et al., 2001; Firmansyah et al., 2024). This sport requires high physical demands both during training and matches. Success in football itself is influenced by several interrelated factors (Stølen, 2005). Performance markers are often used by sports scientists to identify, characterize, and determine training methods in players (Clemente et al., 2016). The use of these markers aims to increase knowledge about what factors most contribute to improving performance and success in the field (Carling et al., 2008). In a previous research report it was also noted that football causes high metabolic and physiological stress during competition (Stølen, 2005). Therefore, the importance of monitoring performance and synchronizing training with actual competition is the main goal of a sports science-based approach.

The internal load of players is usually measured using Heart Rate (HR) monitoring, but it can also use subjective measurements such as the Hopper Index and Rating of Perceived Exertion (Lourenço et al., 2023). HR monitoring is believed to be the most effective method in monitoring the intensity of a player's training in order to achieve aerobic fitness goals and avoid overtraining (Póvoas et al., 2019). In addition, monitoring training loads is also done to maximize physical performance (Gabbett et al., 2014) reduce the risk of injury and disease (Gabbett, 2016; Owen, 2016) to minimize unwanted training results (Foster, 1998), such as a mismatch between training and the demands needed during matches. Research conducted (Pillitteri et al., 2023) shows that the external load generated by each player is different based on the position they play. Midfielders always covered the furthest distance, while central defenders recorded the opposite result. This makes the player who travels the longest distance have a greater burden, so it is possible to experience higher fatigue when compared to other players (Dalen, 2016).

There have been many studies involving semi to professional players for both Global Positioning System (GPS) and Heart Rate (HR) monitoring, but this is in stark contrast to

youth and recreational football players (Marynowicz et al., 2020; Stojanović, 2019). The popularity of football has in fact resulted in an increase in recreational football participation recently. Along with the popularity of the sport usually comes an increase in the frequency of injuries sustained (Ampat et al., 2022). This increase in participation in recreational football may be aligned with one's awareness of the benefits to be gained. Improved musculoskeletal, metabolic, and cardiovascular systems are some of the benefits derived from recreational football training programs if performed appropriately. Specifically, improvements in VO2max and reductions in fat mass and blood pressure during a 12-week recreational football training program (Krustrup et al., 2009). Even these improvements were still found one year later even though the number of sessions was reduced from 3 times a week to 1 time a week (Krustrup et al., 2010).

This is the case with youth football, where researchers have mostly focused on the elite to professional level (Di Salvo et al., 2010; Paul S Bradley, Michele Di Macio, 2010). Very rarely are concerned with the characteristics of young players (Bellistri et al., 2017). Even if observed, there are still few who apply GPS to football players under 12 years old, especially in the 7-a-side format (Bravo-Sánchez et al., 2017; Hernandez-Martin et al., 2020). Monitoring of training load is usually also only done during training sessions, especially during Small Sides Game (SSG) (Castillo-Bellot et al., 2019; Marynowicz et al., 2020), there are still few who observe how to respond during actual match simulations. Studies have shown that proper training load management among young players is essential to help progressive increases in training volume and support their long-term sporting careers (Bourdon et al., 2017).

Physical fitness and health are the main goals in recreational football, while the pattern of coaching in young players aims to lead to competition and achievement. However, these goals will not be achieved if the portion of training done at each level is not appropriate. To our knowledge, observing and comparing the characteristics of young players with recreational players have never been shown to date, even though the study is able to provide an overview of how the player's internal and external load responses if given an intervention with the same duration. Research conducted by (Hendry et al., 2019) states that players' intrinsic motivation will decrease as their age and skill level increase. It is also believed that this can influence the activity profile while in the field.

Therefore, this study aims to see a comparison of how physical demands are described through heart rate responses and activity profiles in young age group soccer players with recreational soccer players who incidentally are included in the adult age category. So that both players and coaches can know the right training program to provide based on the characteristics and goals of each level, especially for the health and welfare of players.

Method

Research Design and Participant

This research design is an observational cohort study with a comparative study method. The research subjects were junior players at the academy and also recreational players at an amateur club. Total subjects participating in this study were n=24 (12 male junior football players with characteristics Age 11.58 ± 0.28 years, 142.25 ± 8.74 cm, 34.5 ± 6.42 kg, playing experience 3.88 ± 0.23) and (12 recreational football players Age 32.7 ± 1.38 years, 170.67 ± 3.92 cm, 73.42 ± 5.33 kg, playing experience 20.33 ± 0.98). In this study goalkeepers were not involved and excluded from the analysis ((Marynowicz et al., 2020). Purposive sampling was carried out to classify subject retrieval. The inclusion criteria in this study are; 1) sample age ranges from 11-12 years, and 30-35 years, 2) actively playing or practicing football at least once a week, 3) joining a football club or community. Provincial-level junior players train 3 times a week with a break of one day and a duration of 120 minutes for each session. Maximum heart rate is calculated using the formula 220 – their age (Fox et al., 1971). The exclusion criteria included are; 1) the subject is not the specified age, 2) is sick or has a history of cardiovascular disease, 3) is in a condition of physical injury, especially in the lower extremities (Hernandez-Martin et al., 2020).

Study Data Collection and Procedurs

In measuring heart rate, the Polar Verity Sense instrument (Polar, Kempele, Finland) can be used. Polar Verity Sense is a wearable device that measures sports performance using inertial sensors, GPS and Electrocardiography (ECG). Researchers input player data according to age, height and weight. Then the device can be turned on by pressing the power button until the sensor is green. After that, the device is placed on the player's left arm (non-dominant arm). Furthermore, the player's heart rate can be detected via bluetooth on the Polar Team software application installed on the 9th Generation Ipad (Apple Inc, California, USA) which claims to be connected up to 150 meters away. In the application monitor, the maximum heart rate, average heart rate, calories expended and percentage of the player's heart rate zone can be seen in real time. This tool has gone through validity and reliability tests with excellent results on both (Navalta et al., 2023).

On the other hand, to determine the physical demand, especially the external load or activity profile of each player, it is done using Catapult One (Catapult, Melbourne, Australia). Catapult itself is a GPS-based device that can be used to measure a variety of player activity profile metrics on the field, including acceleration, deceleration, speed, distance, performance, training load, and the effectiveness of training interventions. Catapult has been used in numerous football studies to provide insights into player performance and the effectiveness of training interventions (Castellano et al., 2015; Goto et al., 2015; Sausaman et al.,

2019). Matches were analyzed with GPS units sampling at 10 Hz and equipped with 100 Hz accelerometers (Catapult Innovations, Victoria, Australia). The speed zones on the Catapult device have been set into five zones namely Standing & Walking (0 - 1 m/s), Jogging (1 - 3 m/s), Low Speed Running (3 - 5 m/s), Moderate Speed Running (5 - 7 m/s) and High Speed Running & Sprinting (7 - 12 m/s). Then for Acceleration at 3 m/s and Deceleration -3 m/s.

Data collection is carried out when both teams undergo regular training by conducting internal simulation games. Where the time or duration of data collection for each team is 15 minutes. However, junior data collection is carried out on a mini field measuring 60 x 40 (m) or with an area per player of 171 m2, while for recreational players it is carried out on a normal field measuring 104 x 69 (m) or with an area of 326 m2 per player. Both fields used in this study are artificial grass which was taken from 07.00 - 09.00 WIB. This research has had an ethical license issued by the Health Polytechnic Bandung which refers to the Helsinki declaration with number No. 12/KEPK/EC/IX/2023.

Statistical Analysis

After the data collection was completed, the data was analyzed using IBM SPSS Version 21. In analyzing heart rate response and profile activity, the Mann-Whitney U test was conducted to determine the difference between junior and recreational players. Before that, test the normality of the data using Kolmogorov Smirnov. In addition, the frequency distribution of the number of acceleration and deceleration (mean and standard deviation) was presented in graphical form.

Results

This research aims to analyze the characteristics of junior and recreational football. Below are the results of the differences between internal and external loads produced during a match of the same duration.

Table 1.
Comparison of heart rate and profile activity between junior and recreational football player

Variable	Junior	Recreational	Overall	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
HRavg (bpm)	166.1 ± 17.2	155.3 ± 10.5	162.3 ± 16.7	0.024*
HRmax (bpm)	193.1 ± 12.3	176.0 ± 10.0	183.7 ± 15.5	0.002*
TD (m)	1507.1 ± 163.8	1314.0 ± 163.6	1410.6 ± 236.2	*NS*
SD (m)	42.8 ± 27.3	83.9 ± 67.5	63.3 ± 54.5	*NS*
TS (m/s)	5.87 ± 0.37	6.53 ± 0.77	6.20 ± 0.68	0.033*
Max Dec (m/s^2)	5.60 ± 0.87	5.29 ± 1.65	5.44 ± 1.30	*NS*
Max Acc (m/s^2)	4.69 ± 0.33	4.35 ± 0.39	4.52 ± 0.39	0.033*

*HRavg = heart rate average, HRmax = Maximum heart rate, TD = Total distance SD = Sprint distance,
TS = Top Speed, Max Dec = Maximum deceleration, Max Acc = Maximum acceleration, NS= Non-Significant. *p-value < 0.05

Table 1 shows significant differences in the variables HRavg 162.3 ± 16.7 ((p = 0.024) and HRmax 183.7 ± 15.5 (p = 0.002) p < 0.05. In addition, the same results can also be seen in the variables TS 6.20 ± 0.68 (p = 0.033) and Max Acc 4.52 ± 0.39 (p = 0.033). Junior players have more average number of acceleration values when compared to recreational players (Figure 1). In addition, the average value of the number of decelerations of junior players is also higher than recreational players (Figure 2).

Table 2.
Difference distance speed zone and time speed zone between player

Variable	Junior	Recreational	*p-value*
	Mean ± SD	Mean ± SD	
DSZ 1 (m)	166.1 ± 17.2	155.3 ± 10.5	*NS*
DSZ 2 (m)	193.1 ± 12.3	176.0 ± 10.0	0.007*
DSZ 3 (m)	1507.1 ± 163.8	1314.0 ± 163.6	*NS*
DSZ 4 (m)	42.8 ± 27.3	83.9 ± 67.5	*NS*
DSZ 5 (m)	0.00 ± 0.00	6.53 ± 0.77	0.006*
TSZ 1 (s)	480.3 ± 95.2	411.0 ± 112.6	*NS*
TSZ 2 (s)	521.9 ± 38.0	468.9 ± 86.6	*NS*
TSZ 3 (s)	96.8 ± 30.9	78.0 ± 34.2	*NS*
TSZ 4 (s)	7.85 ± 4.88	11.6 ± 8.22	*NS*
TSZ 5 (s)	0.00 ± 0.00	3.53 ± 5.90	0.006*

*DSZ = Distance in Speed Zone (m), TSZ = Time in Speed Zone (s) NS= Non-Significant (p > 0.05)

The distance covered per speed zone is one of the preferred variables to assess the performance of football players. Based on table 2, it shows that there is a significant difference in the DSZ 2 distance variable (junior = 193.1 ± 12.3, recreational = 176.0 ± 10.0) (p = 0.007) dan DSZ 5 (p = 0.006) (junior = 0.00 ± 0.00, recreational = 6.53 ± 0.77) dan TSZ 5 (junior = 0.00 ± 0.00, recreational = 3.53 ± 5.90) (p = 0.006). This result can occur because junior football players do not reach zone 5, so there is an imbalance in values in that zone both in distance and time, except for DSZ 2

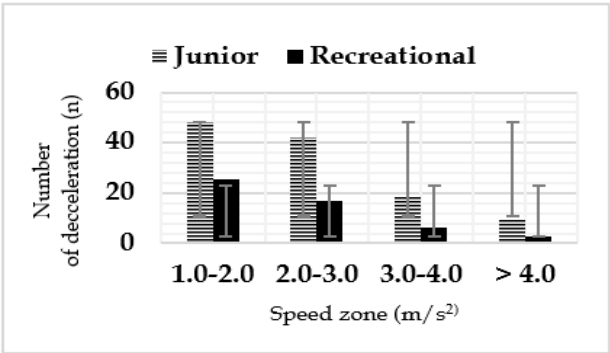

Figure 1. Different of number acceleration of player

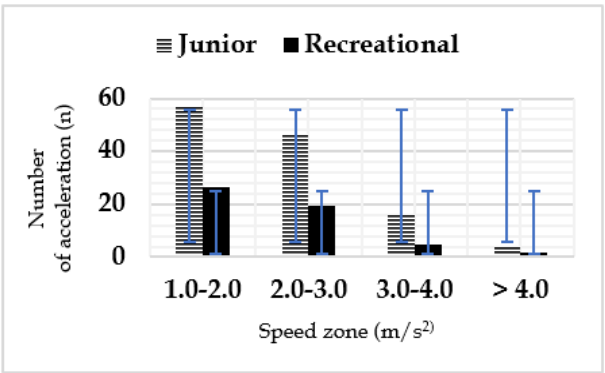

Figure 2. Different of number deceleration of player

Discussion

Internal Load

The purpose of this study was to identify differences in physical demand between heart rate response and profile activity in junior and recreational football players. Total distance, top speed, sprint distance, maximum acceleration and maximum deceleration were recorded to identify global physical demands of players. This study also analyzed how the speed zone differs in the dimensions of distance and time. The results found that Heart Rates (HRs) showed significant differences in both research subjects. Heart rate (HR) is used to monitor players' exercise responses, as well as to measure microcycle and mesocycle exercise intensity during pre-season and in-season periods. (Kalapotharakos et al., 2019).

When viewed from the results of the study that the HRmax of the two research subjects can reach 90-95%. This is in line with research conducted by Maithe (2019), taking into account the average age of each group and the prediction of the corresponding average age HRmax (220 - age), it was verified that at least 95% of their HRmax was achieved. HR in children tends to be higher this is due to children's heart rate increasing as the intensity of exercise increases and is caused by the increased oxygen and energy needs of the body during exercise. HRmax in junior football players was 30 bpm higher than in older players (Capranica et al., 2010). According to Aslan (2013), that the number of players is the main factor affecting responses and technical actions during recreational football matches. In addition, the participation of recreational players is expected to provide sufficient stimulus to improve cardiovascular fitness associated with high exercise intensity. Which is one of the important goals of players participating in recreational football, namely for health. Quantification of heart rate is also very useful information during pre-season in football players.

Profile Activity & External Load

In this study, it was found that there were significant results on profile activity, especially for Top Speed (TS), and Max Acc variables but not Total Distance (TD), Sprint Distance (SD) and Max Dec. The same results were found (Capranica et al., 2001) where there were no differences in inactivity, walking, running, and jumping between 11-a-side and 7-a-side in the 12-year-old age group. In another study it was also stated that no differences were found in the variable total distance traveled during 5-a-side, 8-a-side and 11-a-side matches in players under 10 years old (Loturco et al., 2018). Then in an investigation conducted by Abbot et.al. (2018), showed significant differences in the physical demand generated in the football playing positions during the competition. However, there was no difference in profile activity between substitutes who entered the match at different times (considering 15-minute intervals) (Janusiak et al., 2023). In addition to different tactical and technical roles, each playing position has specific physical demands associated with it. In summary, the training sessions analyzed in the current study have not reached the physical demands of competitive matches in most of the actual physical performance variables (Vicente et al., 2020). Note that in considering the physical demand for different playing positions during a match, the training emphasis should be different (Pettersen & Brenn, 2019).

Total distance traveled is one of the most widely used measures of external load in the evaluation of the amount of work developed by players in training and competition, measured in absolute units (m) (Miguel et al., 2021). The distance found in this study for junior players was 1507 m and 1324 m for recreational players. According to Jagim et.al (2020) the athletes covered about 9800 m of the total distance per 90-minute match and 1019 m (about 10%) at a faster pace than jogging (high-speed distance). In addition, the study also yielded an average HR response of 142 bpm or 74% of HRmax with a peak HR value of 197 bpm which equates to 101% of HRmax at both distance and speed. According to Martin (Hernandez-Martin et al., 2020) physical demand during a multi-match tournament on the same day affects the performance of U10 or junior players. Overall, no statistically significant differences were observed for the total distance traveled between the position groups (Sausaman et al., 2019). Similarly, no significant difference was found between when substitutes entered the match for total distance (Janusiak et al., 2023). In this study, we also found similar results where the total distance traveled between juniors and recreational players did not have a significant difference with the same total game duration, even with different field sizes and number of players (Table 1).

However, the opposite result was found in top speed, there was a significant difference between junior and recreational football (Table 1). This is because recreational players have a neuromuscular and biomotor maturity status when compared to young players who are still in the growth stage. Maturity status is an important factor in the physical development of youth players, especially in relation to their physical capacities and match running performances (Le Gall et al., 2007). The difference in performance between junior and senior players makes it inappropriate to apply the same speed threshold to both (Harley et al., 2010). So that the impact can be seen from the characteristics of the activity profile, especially in Top Speed, recreational players are much faster when compared to young players. This in fact also affects the resulting speed zone, where when recreational players can reach speed zone 5 (7 - 12 m/s) on the other hand young players are only able to reach speed zone 4 (5 - 7 m/s). So, this reinforces that each age group requires different speed zone settings (Goto et al., 2015; Harley et al., 2010). In (Figure 1 & Figure 2) it can also be observed that the number of accelerations and decelerations between young players and recreational players has a significant difference from each zone. Where young players recorded a greater number of accelerations and decelerations when compared to recreational players. It may be that apart

from the more energetic characteristics of young players, the twice smaller area per player also allows players to get more action on the ball in the game. According to (Folgado et al., 2014; González-Rodenas et al., 2022) younger players do tend to play with more individual actions such as running and dribbling.

Furthermore, the different 15 Hz GPS devices showed valid results at the maximum speed reached by the U10 players (< 20 km/h), but these devices would not be valid enough to record the maximum speed in adults, as the reliability decreased with values > 20 km/h (Johnston, 2014). Young football players with high maximal speed can be identified as potential professional players. Therefore, there is a need to obtain results on the maximal speed required across different positions in elite youth players (Murtagh et al., 2018). Measuring the distance traveled at each acceleration and deceleration zone makes it possible to measure the intensity of the displacement, associated with the acceleration and deceleration actions. However, unlike long-distance running, the number of accelerations seems to be a considerable part of the training session (Dalen & Lorås, 2019). All studies evaluating acceleration and deceleration use "m/s/s" as the unit of measurement. However, the same is not the case with respect to the distance covered by the speed zone (Miguel et al., 2021). It is therefore necessary to use the unit "m/s" when evaluating the distance covered by the speed zone, and the unit "m/s/s" when evaluating the acceleration or deceleration zone.

Other research explains that acceleration and deceleration are sensitive to fatigue during a match and thus can provide a reliable measure of physical match performance (Vigh-Larsen et al., 2017). These findings could be attributed to greater neuromuscular fatigue and increased metabolism during exercise through overstimulation (Vicente et al., 2020). This may be due to the insufficient application of small-side game training, which develops more acceleration and deceleration.

These findings can provide recommendations on how the use of activity tracking tools can be adjusted based on age groups and soccer levels, especially regarding the speed zones used. then regarding heart rate and activity on the field, it is recommended that recreational players use smaller fields such as junior players as a method of increasing anaerobic capacity.

Conclusion

The study showed significant differences between junior and recreational players on HRavg and HRmax variables. The use of HR monitoring can indicate the performance of the players' endurance performance during training. Meanwhile, this study also found significant differences between TS and Max Acc variables in PD players. But there is no significant difference in TD, SD, Max Dec between players. Coaches need to use heart rate trackers and work performance metrics to monitor training in football players. Good physical performance needs can determine the ability of physical demand and overcome excessive spikes in HRs that can cause overtraining. This research is a recent study on the comparison between junior and recreational players. It is necessary for future research literature to discuss in more detail the physical characteristics, especially among junior and recreational players.

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Datos de los/as autores/as y traductor/a:

Andika Bayu Putro	andikabayuputro@gmail.com	Autor/a
Awang Firmansyah	awangfirmansyah@unesa.ac.id	Autor/a
Tommy Apriantono	tommy@fa.itb.ac.id	Autor/a
Muhamad Fahmi Hasan	fahmi.hasan@itb.ac.id	Autor/a
Toho Cholik Mutohir	tohoditjora@gmail.com	Autor/a
Muchamad Arif Al Ardha	muchamadalardha@unesa.ac.id	Autor/a- Traductor/a
Achmad Widodo	achmadwidodo@unesa.ac.id	Autor/a
Rizky Maulana	rizky.id199@gmail.com	Autor/a