PHYSIOLOGICAL AND TECHNICAL DEMANDS OF 4 v 4 AND 8 v 8 GAMES IN ELITE YOUTH SOCCER PLAYERS

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Abstract:

Eight elite male soccer players from a Premier League Soccer Academy completed 4 v 4 and 8 v 8 games. The physiological responses to match-play were determined for each player by recording their heart rates during all the games and filming each player to determine individual work-rate profiles and evaluate technical actions. Mean ± SD heart rate for 4 v 4 and 8 v 8 matches were not significantly different (4 v 4, 175 ± 10 beats/min; 8 v 8, 168 ± 6 beats/min). Total distance covered during games was also similar (4 v 4, 778 ± 160 m; 8 v 8, 693 ± 103; $P>0.05$). The total distance covered by walking, jogging and sprinting did not significantly differ with the number of players included in the game. Significant differences were noted for utility (backward and sideways) movements ($P<0.05$) with greater distances covered in 4 v 4 (140 ± 68 m) than 8 v 8 (107 ± 51 m) games. Reductions in the number of players significantly ($P<0.05$) increased the number of individual ball contacts per game from 13 ± 7 in 8 v 8 to 36 ± 12 in 4 v 4. The data from this investigation suggest that the number of players involved does not seem to be a crucial determinant in the demands of match-play. This observation is in contrast to more technically related actions that are significantly influenced by player number.

Key words: *heart rate, work-rate analysis, association football, soccer*

Introduction

The identification and development of young soccer players has become increasingly important to elite soccer clubs over the last decade. This is a direct consequence of legal rulings in the European Court of Human Rights and the inflationary pressures on both wages and transfer fees for elite adult players (Williams & Reilly, 2000). The detection and identification of individuals with the potential to become elite soccer players at an early age ensures that players can receive specialist coaching and training to accelerate the talent development process thereby helping to ensure the future success of the team.

Performance in soccer is a consequence of psychological/social factors, technical and tactical skills and the physiological capabilities of an individual (Bangsbo, 1994). Any development programme undertaken by a young soccer player should consider all these factors though there is frequently a greater focus on the development of the tactical/technical and physiological attributes of players. For participants to improve these elements players must be chronically exposed to effective training sessions (Reilly, 2005). Such training requires a close association to the competitive demands of match-play as well as a consideration of the practical constraints placed on the training programme. Such limitations include the facilities and time available for the sessions and the rules and regulations of the national governing body that determine the developmental process that operates within a soccer club. These considerations have partly prompted a number of recent developments in the training of soccer players. One such advance has been the increasing use of small-sided games as a specific tool for physical conditioning (Rampinini et al., 2007) in the development of young players.

Small-sided games combine both technical/tactical and physiological training stimuli (Rampinini et al., 2007). As a consequence they represent a useful solution to the time restrictions faced by the coaches of elite young soccer players. The physiological responses of adult players suggests that small-sided games can elicit heart rate responses around 90-95% of maximal heart rate (HR_{max}) (Hoff, Engen, Kemi, & Helgerud, 2002) and lead to improvements in both aerobic fitness and physical match performance (Helgerud, Engen, Wisloff, & Hoff, 2001) in addition to providing a technical stimulus. Several factors, related to the organisation of small-sided games are, however, thought to in-

fluence the training stimulus associated with small-sided games (Bangsbo, 1998). These factors could therefore impact upon their ability to be useful tools for training sessions aimed at the development of young, talented players. Few studies (Little & Williams, 2006; Little & Williams, 2007; Owen, Twist, & Ford, 2004) have, however, attempted to systematically investigate the impact of changes in the number of players, pitch dimensions, rules, coach encouragement, etc. on such responses. This would seem an important consideration for all coaches if the effectiveness and time efficiency of these drills as a soccer training stimulus underpins any intervention. Such considerations may be especially crucial for coaches involved in youth soccer. Inappropriate physiological and technical stresses may not only interfere with the normal processes of growth and maturation and lead to injury (Malina, 2003) but lead to psychological stress that may lead to athlete burnout (Kentta, Hassmen, & Raglin, 2001). Taken together these factors may combine to reduce the possibilities of young players developing into elite adult players and hence undermine the objectives of such talent identification programmes.

The aims of the present investigation was therefore to compare the physiological load, as indicated by both heart rate responses and work-rate patterns, and technical demands during 4 v 4 and 8 v 8 elite youth soccer games.

Methods

Participants

Eight male elite youth soccer players volunteered for the investigation, all of whom were physically active, taking part on average in three hours of training and one match per week (mean±SD; age 7±1 years, height 1.3±0.2 m, weight 25.3±3.8 kg, playing experience 2±1 years). The participants were all recruited from a single northwest F.A. Premier League Academy and were considered to be of an elite ability for their age. All the participants gave consent to participate in accordance with the local university's ethical procedures. In an attempt to minimise the effects of maturation all the experimental work was completed within a three week period. All the testing sessions took place at the same time of day to remove the effects of circadian variation on the variables (Reilly & Brooks, 1986). The subjects also completed all sessions in a post absorptive state (~ 2h), having abstained from vigorous exercise during the previous 24h. Each participant's guardian recorded their nutritional and fluid intakes for the 48 h period prior to the first test. This record was copied and returned to the guardian so that the diet could be replicated for the remaining experimental trial(s) in an attempt to standardise the nutritional and hydration status.

Experimental Procedures

All subjects were fully familiarised with the experimental procedures and the requirements of the games prior to participation in the main investigation. This familiarisation involved the completion of three training sessions in which the relevant measurements were obtained from the participants while playing games with identical rules.

Following this familiarisation each participant was filmed while competing in two small-sided games. The order of completion of the different experimental trials was determined by a random numbers table. The number of players was systematically altered on each occasion. On one occasion players played in a 4 v 4 game on a pitch, 30 x 25 m while on the other occasion players played an 8 v 8 match (60 x 40m pitch). To ensure that all games were of a similar technical demand the opposition was selected from the remaining members of the elite under eight squad at the club. Both game formats complied with the regulations of the English Football Association. Each game lasted 10 minutes. All games were timed by a digital stopwatch (Casio HS-3, Casio Electronics Co. Ltd, Guangzhou, China).

Both 4 v 4 and 8 v 8 games employed normal match play rules. The tactical formations used by the players were, however, different for the two game formats. A 1-3-2-2 formation, using one goalkeeper, three defenders, two midfield players and two strikers was utilised in the 8 v 8 matches. Conventional positioning was not used in the 4 v 4 games as a 1-2-1 diamond formation was used. A large number of footballs were placed around the perimeter of each pitch at approximately 5 m intervals to ensure a rapid restart of play. All games were preceeded by a standardised warm-up period of 10 minutes followed by 2 minutes of passive recovery. All games were completed indoors to minimise the influence of environmental variables.

Physiological and Technical Evaluations

Heart rate was recorded following the warm-up, using short-range radio telemetry (Polar Team System, Polar Electro OY, Kempele, Finland). Heart rate was continuously monitored throughout the small-sided games and recorded at 5 s intervals. After each session all heart rate data was downloaded to a PC via computer interface using dedicated software (Polar Precision S-Series Software SW 3.0; Polar Electro, Kempele, Finland) and stored. The mean heart rates for each minute were calculated for each participant for each game and used for analysis to provide an indication of the overall intensity of the small-sided game. The recorded heart rate was also divided into 5 intensity zones (>50% HR_{max}, 50-60 % HR_{max}, 60-70% HR_{max}, 70-85% HR_{max} and <85% HR_{max}). The time

spent within in each intensity zone was calculated to provide an additional indication of the physiological stress associated with match-play.

All players were filmed for the entire 10 min duration of the match using a video camera (Sony, CCDTRV218, Japan) to determine their work-rate profiles during each small-sided game. The video camera was positioned on a tripod (Vanguard VT-131, Vanguard, Michigan, USA) 5 m from the side of the pitch at the half way line. Four players were filmed in each game (two from each team). None of the participants had any knowledge that they were being recorded at that specific moment. The video tapes were then replayed on a television monitor (Sanyo, CE-24WN4-B) using a VHS tape optimiser (Mitsubishi, HS-550V, United Kingdom). To analyse each discrete activity profile a hand notation system was used. Activities were divided into four categories. These were walking, jogging, sprinting and utility (backwards and sideways) movements. The total distance covered in each game in each activity classification was estimated according to the stride length method devised by Reilly and Thomas (1976). These values were then used to calculate the total distance covered during the game. The number of technical actions completed by each player was also recorded. These were cumulated for the entire 10 min game period and reported as the total number of ball contacts.

Drust, Atkinson, & Reilly (in print) state the importance of ensuring that observations made during game play are reliable. In this context, reliability can be defined as the agreement between repeated observations by the same observer (intra-reliability) and between repeated observations by different observers (inter-reliability) of the actions that make up the activity profile. Inter- and intra-reliability were assessed by the re-analysis of one designated small-sided game by the investigators. These observations were completed at least 7 days apart to prevent any learning effects influencing the data. The level of agreement for the work rate analysis was determined using the methods of Van Der Mars (1989). This method uses the percentage agreement between two repeated observations to provide an indication of the consistency of the data. The percentages of exact agreements for both inter- and intra-reliability was 93%. This score is above the value suggested by Van Der Mar (1989) as suitable for a complex system.

Statistical Analysis

Data are expressed as means±SD. All data sets were assessed for the assumption of normality using the Shapiro-Wilks test for normality of distribution statistic. A student's *t*-test with repeated measures (within subject) was employed to evaluate the differences in between heart rate responses, the total distance covered, the total distance covered in each activity category and total number of ball contacts. The Bonferroni procedure was applied to correct for alpha-inflation. All statistical analyses were carried out using SPSS Statistical Analysis Software (SPSS® Version 12.0.01 for Windows®, Chicago, Illinois, USA).

Results

The mean ± SD heart rate responses for the 4 v 4 and the 8 v 8 small-sided games are presented in Figure 1. Mean heart rate responses for the 4 v 4 games was 175±10 beats/min. This value was not significantly different from the mean value observed in the 8 v 8 games (168±6 beats/min). The percentage time spent in each heart rate zone was also similar between the two types of games ($P > 0.05$) (See Figure 2).

The mean ± SD total distance covered was slightly greater in the 4 v 4 games (778±160m) compared to that completed in 8 v 8 (693±103m) though this difference did not reach any statistical significance. Figure 3 presents the mean±SD total distance covered in each discrete activity category. The total distance covered by walking (4 v 4, 181±72m; 8 v 8, 187±77m), jogging (4 v 4, 315±86m; 8 v 8, 334±69m) and sprinting (4 v 4, 143±64m; 8 v 8, 71± 7m) did not differ significantly with the number of players in the game. Significantly ($P<0.05$) greater distances were, however,

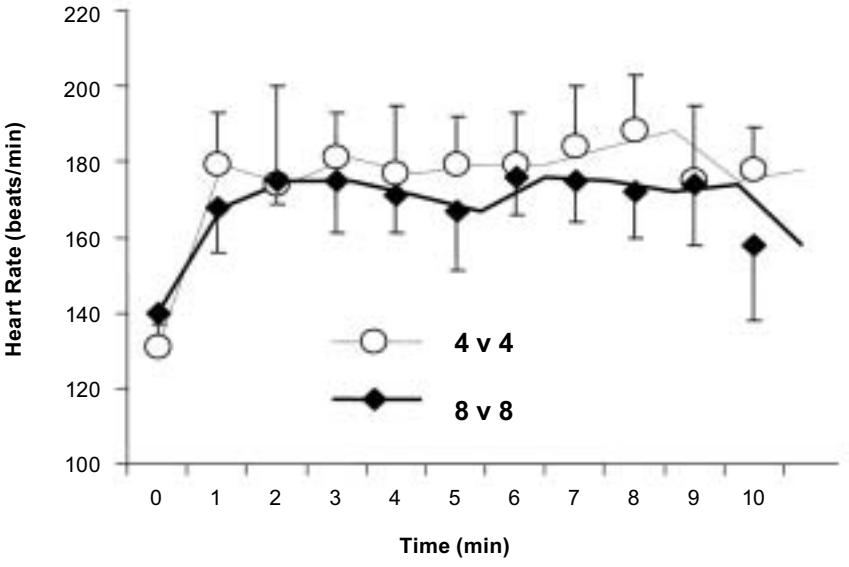

Figure 1. Mean±SD heart rate responses for 4 v 4 and 8 v 8 small-sided games

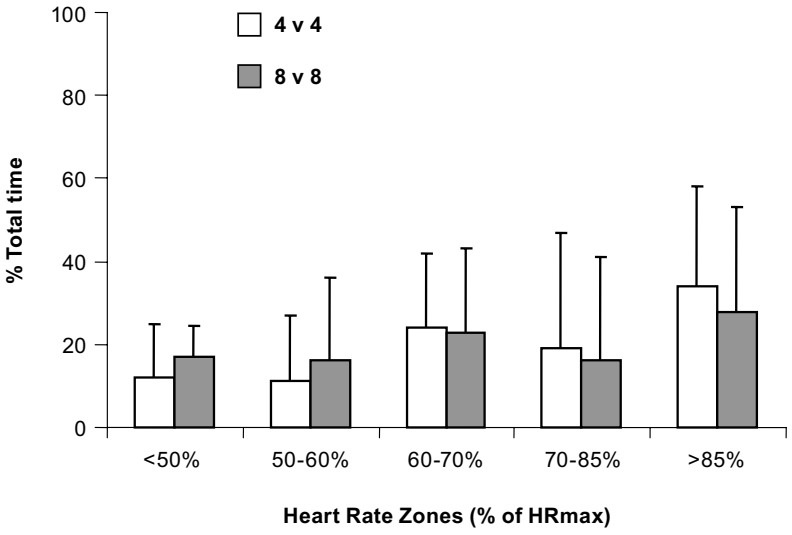

Figure 2. Mean±SD percentage time in each specific heart rate zone for 4 v 4 and 8 v 8 games

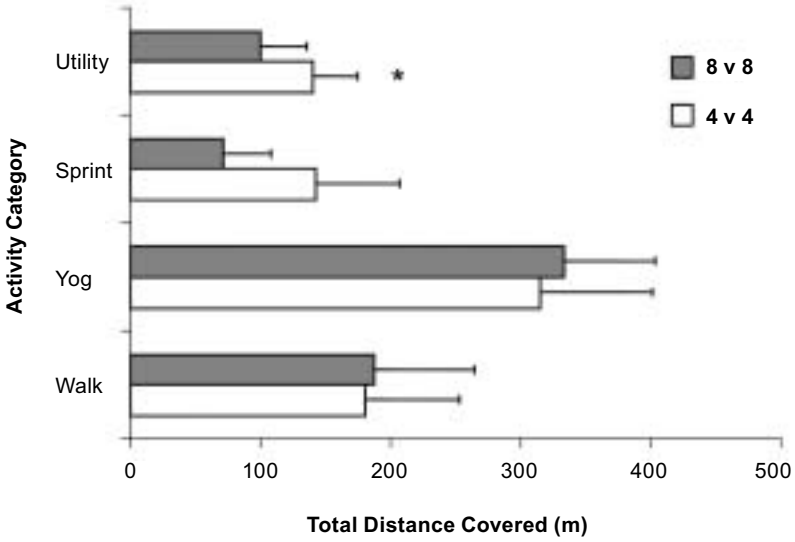

*Figure 3. Mean±SD work –rate profiles for 4 v 4 and 8 v 8 games. * significant difference between conditions (P<0.05)*

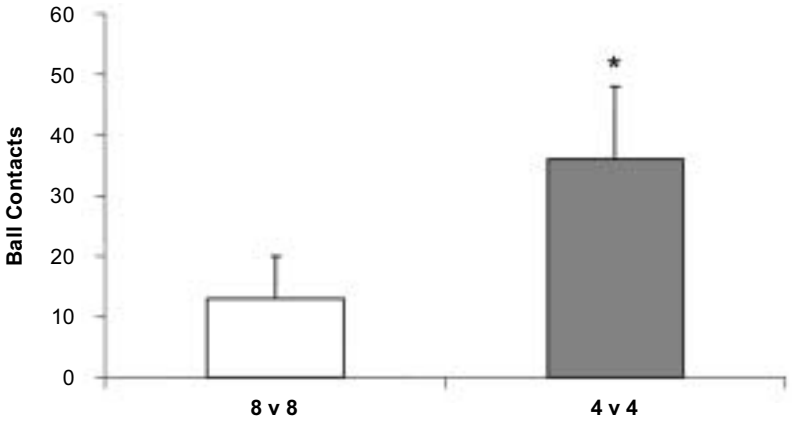

*Figure 4. Mean± D ball contacts for 4 v 4 and 8 v 8 games. * significant difference between conditions (P<0.05)*

covered in utility movements in 4 v 4 (140±68m) compared to 8 v 8 matches (107±51m).

The technical requirements of the game were evaluated by examining the total number of ball contacts. Reducing the number of players in the game significantly increased the number of individual ball contacts per game from 13±7 in 8 v 8 to 36±12 in 4 v 4 ($P<0.05$; see Figure 4).

Discussion and conclusions

The aim of the present study was to compare the physiological load and technical requirements during 4 v 4 and 8 v 8 games in elite youth soccer. Few studies have comprehensively evaluated heart rate responses alongside work-rate analysis in youth soccer despite the value of such data in assisting coaches to develop suitable practice-sessions for elite young players. Our results demonstrate that, within the limits of our experimental training protocols, the number of players does not seem to alter the heart rate responses observed within small-sided games. The manipulation of the number of players within a team does, however, seem to have a small impact on the work-rate profiles observed. Importantly, the number of players included significantly affects the technical requirements placed on the players. This may indicate that careful organisation of practice is crucial if the technical development of players is a specific focus in training sessions.

The mean±SD heart rate responses to the 4 v 4 and 8 v 8 games were similar in the current investigation. This is in contrast to the data published by Rampinini et al. (2007) for adult players and Platt, Horn, Williams, & Reilly, (2001) for youth soccer players. Direct comparisons between the studies that have examined small-sided games may, however, be difficult as the specific parameters used to control the training stimulus (e.g. instructions, rules, pitch

size, etc.) vary widely. These factors are also likely to influence the physiological responses (Bangsbo, 1998) and hence confound a clear understanding of the impact of player number on the physiological stress associated with small-sided games.

It is clear that this type of training, irrespective of the number of players, presents a significant stress to the cardiovascular system. The mean heart rate during the 4 v 4 and 8 v 8 games equated to approximately 83 % and 79% of HR_{max}. Close examination of Figure 2 illustrates that both game formats result in heart rates in excess of 85% of HR_{max} for durations in excess of a quarter of the playing time. This stimulus would seem suitable for the development of aerobic fitness in these populations if the guidelines advocated by Hoff (2005) for adult players are relevant to this specific population.

The work-rate profiles observed in both game formats seem to be similar in pattern to those observed in adult elite 11-a-side match-play (Rienzi, Drust, Reilly, Carter, & Martin, 2000; Reilly & Thomas, 1976). Low intensity activities, such as walking and jogging, accounted for approximately 68% and 75% of the total distance covered for 4 v 4 and 8 v 8 games respectively. High intensity activity was performed less frequently in both types of games (between 10 and 19%). This would suggest that such small-sided games are predominantly aerobic in nature with small amounts of anaerobic energy provision used to support the intense exercise periods.

The work-rate profiles of players obtained in this investigation also indicates a similar physiological load between the 4 v 4 and the 8 v 8 games. No significant differences were observed in either the total distance covered or the distance covered by walking and jogging between games. Close analysis of the data indicates that a greater distance was covered by sprinting in the 4 v 4 games than the 8 v 8 games though this difference did not reach statistical significance. Such trends have also been observed by Platt et al. (2001). This may suggest that the requirement to perform high intensity efforts is increased when player number is reduced. Additional research may be required to clarify these observations.

Utility movements are frequently used by players when defending against individual opponents or when returning to strategic positions with a requirement to view all of the elements of the game. Significantly greater distances were observed in the utility movements in 4 v 4 games. This is similar to the findings of Grant, Williams, Dodd, & Johnson (1999). Such changes may be a consequence of the different tactical requirements placed on the individual players when the number of players is altered. The 8 v 8 games restricted individual players to specific defensive, midfield and attacking positional roles. The 4 v 4 games, in comparision, utilised a much more fluid playing pattern in which all the players were required to complete both defensive and attacking actions. This may place additional requirements on players, especially in relation to defensive actions that may necessitate a greater amount of backward and sideways movements. Additional analysis of these formations, using a more detailed technical analysis in combination with individual's work-rate profiles, may support these ideas in future research.

The inclusion of match-specific activities such as passing, heading, tackling, etc. in small-sided games will make the training stimulus more specific to the demands of the sport (Rampinini et al., 2007) and hence increase the efficiency of training. The evaluation of the technical demands of different small-sided games is therefore an important consideration of such drills even though few studies have attempted to investigate such data. The technical requirements of the two styles of games were evaluated by obtaining simple frequency counts relating to the number of ball contacts for each player during the 10-minute game duration. This data clearly illustrated that the technical requirements placed on players during 4 v 4 match-play were greatly increased compared to those observed during 8 v 8 match-play. This would suggest that the number of players should be carefully considered by coaches in their organisation of practice if the technical development of players is important.

In conclusion, our data indicate that small-sided games impose substantial physiological demands on young players irrespective of the number of players involved in the game These physiological demands were not, within the limits of our experimental training protocols, dependent on the number of players involved in the game. This observation is in direct contrast to more technically related actions that are significantly influenced by player number. This would suggest that activities that include small numbers of players can deliver a more effective multi-component training stimulus while maintaining the same degree of cardiovascular strain as a large group activity.

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FIZIOLOŠKI I TEHNIČKI ZAHTJEVI IGRANJA MALOG NOGOMETA 4 PROTIV 4 I 8 PROTIV 8 KVALITETNIH MLADIH NOGOMETAŠA

Sažetak

Uvod

Igranje sportske igre na igralištu manjemu od propisanoga pravilima igre vrlo je ekonomičan trenažni sadržaj s aspekta vremena jer je to dobra prilika za tehnički, taktički i fizički razvoj igrača. Promjene u strukturi trenažne jedinice imaju određene posljedice u vidu fizičkih i tehničkih zahtjeva koji se postavljaju pred igrače. Utjecaj takovih promjena do sada se još nije sustavno istraživao, osobito ne u radu s djecom. Cilj je ovoga istraživanja procijeniti fiziološke i tehničke zahtjeve koje pred mlade kvalitetne nogometaše postavlja igranje malog nogometa 4 protiv 4 i 8 protiv 8.

Metode

Osam kvalitetnih mladih igrača iz Akademije nogometne premijer lige (aritmetička sredina ± standardna devijacija: dob 7 ± 1 godina, tjelesna visina 1,3 ± 0,2 m, tjelesna masa 25,3 ± 3,8 kg, trenažno iskustvo 2 ± 1 godina) odigralo je dvije malonogemetne utakmice 4 protiv 4 i 8 protiv 8. Svaka utakmica trajala je 10 minuta. Fiziološke reakcije svakog ispitanika na zahtjeve igre praćene su monitorom srčane frekvencije (Polar Electro, Kempele, Finska). Svaki je igrač i snimljen tijekom utakmica video kamerom (Sony CCDTRV218, Japan), kako bi se kasnije mogao načiniti radni profil svakog ispitanika. Kasnije su snimljene vrpce analizirane pomoću ručnog notacijskog sustava u kojemu su se bilježile i tehničke akcije i kretanje igrača po terenu.

Rezultati, rasprava i zaključak

Aritmetičke sredine i standardne devijacije srčane frekvencije nisu se statistički značajno razlikovale u igri 4 protiv 4 i 8 protiv 8 (4 v 4, 175 ± 10 otk/min; 8 v 8, 168 ± 6 otk/min). I vrijednosti ukupno prijeđene udaljenosti u obje utakmice, procijenjene izračunavanjem duljine koraka u raznim vrstama kretanja, bile su slične (4 v 4, 778 ± 160 m; 8 v 8, 693 ± 103; $p>0,05$). Ukupne udaljenosti prevaljene hodanjem, trčkaranjem i sprintanjem nisu se razlikovale bez obzira na broj igača u igri. Značajne razlike su dobivene za pomoćna kretanja (unatrag i bočno) ($p<0,05$) kojima su prevaljene veće udaljenosti u igri 4 protiv 4 (140 ± 68 m) nego u igri 8 protiv 8 (107 ± 51 m). Međutim, kada su se te udaljenosti izrazile kao postotak ukupno prevaljenih udaljenosti, dobiveni su vrlo slični akcijski profili svih igrača za svaku utakmicu. Naime, igrači su, u postotku tijekom utakmice, hodali, trčkarali, sprintali ili izvodili pomoćne kretnje 24 %, 44%, 19% i 13 % u igri 4 protiv 4 te 27%, 48%, 10% i 15 % u igri 8 protiv 8. Tehnički zahtjevi, predstavljeni aritmetičkom sredinom i standardnom devijacijom broja dodira s loptom, ovisili su o broju igrača u utakmici. Smanjenje broja igrača značajno ($p<0,05$) povećava broj pojedinačnih dodira s loptom po utakmici s 13 ± 7 u igri 8 protiv 8 na 36 ± 12 u igri 4 protiv 4.

Podaci dobiveni u ovom istraživanju ukazuju na to da igranje na manjem igralištu s manjim brojem igrača predstavlja fiziološki dosta zahtjevnu aktivnost za mlade igrače. Čini se, međutim, da broj igrača u utakmici nije presudna determinanta tih fizioloških zahtjeva kada se radi o mladim igračima ispitivane dobi. Taj nalaz je u suprotnosti s tehničkim zahtjevima na koje broj igrača u igri znatno utječe. Dobiveni rezultati upućuju na zaključak da aktivnosti koje uključuju manji broj igrača mogu predstavljati učinkovitiji multikomponentni trenažni podražaj, zadržavajući podjednaku razinu kardiovaskularnoga opterećenja (stresa).