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# The Relationship between internal and external load in intensive ball drills in young sportspeople

## Preliminary Study

### Abstract

The aim of this preliminary study was to analyse the training load produced by two physically demanding technical-tactical drills in soccer players of different age groups. Sixteen male players (U16: n = 8, U15: n = 8) performed 2 small-sided games (SSGs) drills: a 4 *vs* 4 possession in a "double square" pitch (3 x 4-min), and an "in/out" possession with regular goals and goalkeepers (20-min total duration, 2 *vs* 2 to 4 *vs* 4). The external load was monitored using a GPS device, and the rate of perceived exertion (RPE) was recorded at the end of each session. The 4 *vs* 4 possession showed a higher training intensity than the "in/out" drill as revealed by higher average metabolic power, distance covered per minute, equivalent distance per minute, and RPE. On thecontrary, the percentage equivalent distance, and high intensity acceleration/deceleration were higher in the "in/out" possession. These differences between examined drills were observed both in the U15 and U16 age group. Finally, in both the drills and for all examined load variables, the training intensity was overall higher in the U16 than in the U15 group. In conclusion, the 4 *vs* 4 possession is more physically challenging than the "in/out" possession, being more focused on physical than on technical aspects. U16 players are more capable than U15 to produce the maximum effort in the 4 *vs* 4, and thus are more ready to perform optimally that kind of drill.

**Key words:** soccer - metabolic power - GPS - RPE

### *Riassunto*

*Questo studio preliminare ha analizzato il carico di allenamento di due esercitazioni tecnico-tattiche a elevato impegno fisico in calciatori di età differenti. 8 calciatori Under 16 e 8 Under 15 hanno eseguito 2 SSGs (Small Sided Games) in diverse modalità: un 4 vs 4 in "doppio quadrato" (3 x 4') e mini-partite, con la presenza del portiere, in "gabbia" (20' totali, dal 2 vs 2 al 4 vs 4). Gli indici di carico esterno sono stati monitorati attraverso un sistema GPS, ed è stata registrata la fatica percepita (RPE). Il 4 vs 4 ha mostrato un'intensità complessivamente maggiore rispetto alla gabbia per potenza metabolica media, distanza al minuto, distanza equivalente al minuto ed RPE. Al contrario, un'intensità maggiore è emersa nella "gabbia" per percentuale di distanza equivalente e accelerazione/decelerazione ad alta intensità. Tali differenze tra le esercitazioni sono risultate pressoché simili negli Under 15 rispetto agli Under 16. Infine, l'intensità delle 2 modalità di SSGs è risultata complessivamente maggiore negli Under 16 per tutte le variabili esaminate. In conclusione, il 4 vs 4 è più intenso della "gabbia", essendo un lavoro più focalizzato su aspetti fisici che tecnici. I calciatori di categoria Under 16 riescono a esprimere un impegno maggiore nel 4 vs 4 e appaiono quindi più pronti a svolgere in modo ottimale tale esercitazione.*

**Parole chiave:** calcio - potenza metabolica - GPS - RPE

## Introduction

This study presents a preliminary research in which two intensive drills were examined in football players of two different age groups. As there are no specific data in literature on the variables examined in the proposed drills, it is not possible to compare them with previous

studies, but only to comment what was observed, on the basis of general remarks suggested by practical experience.

As reported by Hill-Haas et al. (1), the Small Sided Games (SSGs) are usually considered as a means of specific training for football. They basically refer to drills in which the size of the field, the number of players and some rules of the game are modified with respect to the classic 11 vs. 11, in order to give different training stimuli to the players, depending on whether the objective is more focused on physical skills or on technical-tactical ones. The SSG training has several advantages: first, it is possible to train at the same time the technical-tactical and physical qualities of the player with drills that reflect the real game situation; furthermore, the SSGs are more motivating for players compared to training without the ball and guarantee good flexibility for load modulation, thanks to the possibility of varying their different parameters (number of players, size of the field, rules, etc.). However, the SSGs also have some limits, that is the plateau effect being difficult to achieve for well trained players, the difficulty of replicating the most intense moments of the competition, the higher probability of contact injuries and the necessary presence of multiple coaches to control and keep the intensity high. When using SSGs in training, however, it is essential to measure the training load obtained in an accurate and systematic way, especially with reference to exercise intensity. Several indexes exist for load assessment:

1) indexes of internal load, such as heart rate (HR, usually assessed with respect to HR max), blood concentration of lactic acid and level of perceived exertion (Rate of Perceived Exertion, RPE). Moreover, all the methods currently available to assess intensity during the SSGs have specific advantages, but also limitations. This is why it has been suggested that the SSGs be better monitored through a combination of different measures of intensity of the internal load (2). By analyzing the previous studies, in which load intensity in the SSGs has been assessed through the parameters mentioned above (see for example the Review of Hill-Haas et al. (1)), it may be observed that the increase in field size and the decrease in the number of players lead to higher Heart Rate (HR), Lactate and RPE (2). The combined effect of the two variables is also interesting: the intensity of the game, in fact, seems to decrease when the number of players increases and the size of the field decreases. Another factor that can affect the intensity of the drill is the type of rules adopted and the presence or absence of goalkeepers. The effects of the latter variable, however, are not yet clear: for example, some authors have shown that the presence of goalkeepers involves a decrease in the HR of the players (3), while other studies show an opposite effect (4). Finally the intensity of the SSGs is very much influenced by the relationship between work and recovery and by the spur by the technical staff (2);
2) indexes of external load have been introduced over the past few years through a first measurement with GPS at 1 Hz, and today it is already possible to measure at 20 Hz. One of the aspects arising from these measurements is the possibility to assess how the variation of the playing surface, when the number of players remains the same (5 vs. 5 plus the goalkeeper), results in a variation of the distance covered in total, of the average speed and of other variables measured through GPS systems, including some technical-motor behaviour (5). In a recent study by Gaudino et al. (6), it was mainly observed that the total distance, the distance covered at very high speed, as well as absolute maximum speed, accelerations and decelerations increase as the size of the field increases (10 vs 10> 7 vs 7> 5 vs 5). Furthermore, the total distance, the distance covered at very high and maximum speed, absolute maximum speed and absolute maximum acceleration and deceleration were higher in SSGs with goalkeepers and goals (SSG-G) compared to the SSGs aimed at ball possession (SSG-P). On the other hand, the number of accelerations and decelerations of moderate intensity and the total number of speed variations were greater when the size of the field decreased (5 vs 5> 7 vs 7> 10 vs 10) both in the SSG-G and in the SSG-P.

## Aim of the Study

Even in the youth sector the SSGs are widely used in modulating load intensity through field size, use of specific rules, number of players and spur of the coach. As shown by McMillan et al. **(7)** the use of SSGs can lead to very high load intensities (up to 90% and more of HRmax) being comparable to those of dry resistance trainings such as interval training, and producing the same adaptations over time (**8)**. In literature there are still no studies that have analyzed the same drills in different age groups, and there is no evidence about them. From a practical point of view, however, it is crucial to know the characteristics of the drills which are most appropriate for the various age groups, in order to propose them in the most appropriate and specific way. Therefore, in our research we pursued the following objectives:

1) assess the differences in physiological impact of two technical-tactical drills (SSGs) entailing a high metabolic effort, through the measurement of external and internal load;
2) assess the impact of individual drills in two different age groups: Under 15 and Under 16.

## Materials and methods

After a familiarization in two sessions, 16 players in categories U15 (n = 8) and U16 (n = 8) (Tab. I) executed two ball drills, in different sessions and not on consecutive days, for the development of the metabolic

**Table I.** Anthropometric data of the players in the two age groups examined (average and St. dev.).

| U 15 | | | | U 16 | | | |
|---|---|---|---|---|---|---|---|
| | Height (m) | Weight (kg) | BMI | | Height (m) | Weight (kg) | BMI |
| Mean | 1,70 | 57,40 | 17,13 | Media | 1,80 | 69,50 | 21,35 |
| St. dev. | 0,08 | 7,74 | 6,08 | Dev. st. | 0,04 | 4,57 | 0,98 |

and technical-tactical components. Load intensity was monitored through the assessment of perceived exertion (RPE), as measured by the Borg Scale (CR 10). The RPE was collected 10 minutes after the end of the exercise for the in/out and, both after each series and at the end, for the double square. The external load was instead measured through a GPS system (K-sport, 10 Hz, software K-fitness). The exercises were:

1 The "double square" (Tab. II), consisting of a 4 vs. 4 in a square of 15 x 15 m for 1', followed by a change of square, called by the coach, to go to a 20 x 20 m square placed at a distance of 15 m, for 1 ', all repeated twice (tot. 4 '). The rest between repetitions was 2'. There were three repetitions, each respectively of 4 ', for a total of 16';
2 in/out (Tab2 in/out (Tab. III) (proposed by Capanna), which consisted of two teams of 6 players. In turn, according to the diagram below, 2-3-4 pairs of players were called to play in the pitch (30 x 20m) and faced each other in a possession with finalization. In case of a 2 vs 2, game time was 60", for 3 vs 3 game time was 75", for 4 vs 4 game time was 90". Exchange time between players in the pitch was 15". The overall work was 20', while it was 579" for each player in case of players 2-3-4-5-6, and 495" for player 1.

The following tables show some details about the features of the drills used. The variables of external load being analyzed, in accordance with Osgnach et al**. (9**), have been:

1 average metabolic power (W / kg);
2 distance per minute (m);
3 equivalent distance per minute (m);
4 percentage of equivalent distance (%);
5 high intensity speed (m)> 5 m / s;
6 high intensity acceleration (m),> 2 m / s * 2;
7 high intensity deceleration (m), <-2 m / s 2 *;
8 intensive metabolic power (m),> 20 w / kg.

The variable which was analyzed, and which represented internal load, was **(10)**: RPE (points, arbitrary units). To test the effect of the two drills (4 vs 4 and in/out), of the age of the players (Under-15 and Under-16) and of their interaction on various dependent variables observed, 2 x 2 ANOVA were carried out for repeated measures, with age group as a factor among the subjects and type of drill as a factor within the subjects. The analyses were performed with SPSS software, Version 14. The level of significance was set to $p < 0.05$.

**Table II.** Features of the "double square" drill (4 *vs* 4).

| 1st Possession double square | |
|---|---|
| Pitch 1° (m) | 15 x 15 |
| Pitch 1° ($m^2$) | 225 |
| Area ($m^2$) x player pitch No. 1 | 28,1 |
| Pitch n° 2 (m) | 20 x 20 |
| Pitch n° 2 ($m^2$) | 400 |
| Area ($m^2$) x player pitch No. 2 | 50 |
| Distance (m) | 15 |
| No. players | 16 (2 x 4 *vs* 4) |
| No. of players (team) | 4 |
| Tot. duration (min) | 16 |
| Net. duration (min) | 12,5 |
| Exercise duration (min) | 4 |
| Recovery (min) | 2 |
| **2nd In/Out possession with regular goals** | |
| Pitch (m) | 30 x 20 |
| Pitch ($m^2$) | 600 |
| Area ($m^2$) x player field | 75-100-150 |
| No. of players | 12 |
| No. of players | 6 |
| Tot. duration (min) | 20 |
| Net. duration (min) | 17 |
| Exercise duration | 1,5-1,25-1 |
| Recovery (min) | 0,15 |

## Results

Table IV shows the descriptive statistics for the different load variables analyzed, divided according to age group and type of drill. Tables V, VI, and VII show instead, for each of the variables, the significance of the main effects and of the interaction, such as differences in percentage between the two age groups and between the two types of drill. The results showed that in drill 4 vs 4 the values of total intensity of the drill were higher than in the in/out with regard to the following variables: average metabolic power, distance per minute, equivalent distance per minute and RPE (Tab. V). Conversely, higher values were observed in

**Table III.** Description of the in/out possession drill (Rec. = Recovery) (Capanna).

| Players | Matches | | | | | | | | | | | | | Game | Rec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | R | 1 | R | 1 | R | 1 | R | 1 | 1 | R | 1 | R | 1 | 495” | 375” |
| 2 | R | 2 | R | 2 | R | 2 | R | 2 | 2 | R | 2 | R | 2 | 570” | 450” |
| 3 | 3 | R | 3 | R | 3 | 3 | R | 3 | R | 3 | R | 3 | R | 570” | 450” |
| 4 | 4 | R | 4 | R | 4 | R | 4 | R | 4 | R | 4 | 4 | R | 570” | 450” |
| 5 | 5 | R | 5 | R | 5 | 5 | R | 5 | R | 5 | R | 5 | R | 570” | 450” |
| 6 | R | 6 | 6 | R | 6 | R | 6 | R | 6 | R | 6 | R | 6 | 570” | 450” |
| Game time | 75” | 75” | 90” | 60” | 90” | 90” | 60” | 90” | 90” | 60” | 90” | 75” | 75” | | |

**Table IV.** Descriptive statistics (mean and St. dev.) of the variables analyzed.

| | 4 *vs* 4 | | In/Out | |
|---|---|---|---|---|
| | U15 | U16 | U15 | U16 |
| Average metabolic power (W/kg) | 7,52 ± 1,38 | 8,49 ± 0,98 | 6,6 ± 1,42 | 7,33 ± 1,04 |
| Distance per minute (m) | 79,89 ± 12,21 | 87,86 ± 8,49 | 66,83 ± 11,79 | 73,39 ± 8,94 |
| Equivalent distance per minute (m) | 97,06 ± 17,86 | 109,8 ± 12,49 | 85,19 ± 18,21 | 94,89 ± 13,45 |
| Percentage of equival. dist. (%) | 20,82 ± 4,92 | 24,88 ± 3,8 | 26,92 ± 4,38 | 29,07 ± 3,52 |
| Speed to HI (m) | 117,41 ± 82,67 | 146 ± 74,46 | 128,4 ± 108,3 | 165,3 ± 87,76 |
| Acceleration to HI (m) | 78,24 ± 32,2 | 98,84 ± 21,69 | 104,6 ± 35,5 | 118 ± 24,13 |
| Deceleration to HI (m) | 79,24 ± 29,99 | 99,17 ± 22,89 | 104,6 ± 36,8 | 120,2 ± 24,9 |
| Metabolic power to HI (m) | 261,06 ± 103,9 | 317,7 ± 60,36 | 279,5 ± 121,7 | 340,1 ± 93,07 |
| | 4 *vs* 4 | | In/Out possession | |
| | U15 | U16 | U15 | U16 |
| RPE (points) | 3,95 ± 0,52 | 6,44 ± 1,09 | 3,68 ± 0,74 | 5,34 ± 0,77 |

the in/out drill” compared to 4 vs 4 for the percentage of equivalent distance and high intensity acceleration and deceleration. There were no significant differences, instead, between the two types of drill ($p > 0.05$) with regard to metabolic power and high intensity speed. These differences between drills were overall similar in the Under 15 and the Under-16, because no variable (except RPE) showed a significant interaction between age group and type of drill. In the case of RPE, the level of perceived exertion was similar between the two drills in the Under-15, while Under-16 perceived the 4 vs. 4 as more challenging with respect to the in/out. As for the effect attributable to age (regardless of the type of drill) intensity was found to be higher in the Under 16 in reference to all the load variables examined.

## Variables of external load

See Tables V, VI and VII.

## Variable representative of internal load

See Tables VIII, IX and X.

## Discussion and conclusions

This study has presented a preliminary inquiry in which two high-intensity drills have been examined in players of two age groups (U15 and U16).

As there are no specific data in literature on the variables examined in the proposed drills, it is not possible to compare them with previous studies, but only to comment what was observed, on the basis of general remarks suggested by practical experience, and comparisons can be made with the studies conducted so far. What chiefly emerges is that a drill such as the 4 vs. 4, where there is a 4 minute-workout without pause, is more demanding from all points of view with respect to the in/out: the work is therefore more focused on technical aspects than on physical ones, and is probably less motivating for the players as it does not include finalizing. However, high intensity accelerations (> 2 m / s2) and decelerations (<-2 m / s2) have showed higher values in the in/out than in the 4 vs 4. It can be assumed that this is due to the presence of goalkeepers and thus of the goal, as well as to the size of the pitch and to the fact that not only ball possession, but also attacking and defending were

**Table V.** Percentage differences between drills for external load variables. The value is specified in the column which refers to the type of drill with the highest value.

| | For training | | |
|---|---|---|---|
| | 4 *vs* 4 > in/out | In/out > 4 *vs* 4 | p |
| Average metabolic power (W/kg) | 14% | | p = 0,000 |
| Distance per minute (m) | 18% | | p = 0,000 |
| Equivalent distance per minute (m) | 14% | | p = 0,000 |
| Percentage of equival. Dist. (%) | | 24,2% | p = 0,000 |
| Speed to HI (m) | | 2,4% | p = 905 |
| Acceleration to HI (m) | | 24,9% | p = 0,001 |
| Deceleration to HI (m) | | 24% | p = 0,002 |
| Metabolic power to HI (m) | | 2,6% | p = 0,732 |

**Table VI.** Percentage differences between age groups for the different variables of external load.

| | By age | |
|---|---|---|
| | U16 > U15 | p |
| Average metabolic power (W/kg) | 16% | p = 0,000 |
| Distance per minute (m) | 13,3% | p = 0,000 |
| Equivalent distance per minute (m) | 16,3% | p = 0,000 |
| Percentage of equival. Dist. (%) | 14,1% | p = 0,005 |
| Speed to HI (m) | 43,2% | p = 0,000 |
| Acceleration to HI (m) | 24% | p = 0,004 |
| Deceleration to HI (m) | 25% | p = 0,003 |
| Metabolic power to HI (m) | 27,7% | p = 0,002 |

**Table VII.** Significance of the interactions between age group and drill type for the different variables of external load analyzed.

| | Interaction |
|---|---|
| | p |
| Average metabolic power (W/kg) | p = 0,630 |
| Distance per minute (m) | p = 0,518 |
| Equivalent distance per minute (m) | p = 0,621 |
| Percentage of equival. Dist. (%) | p = 0,444 |
| Speed to HI (m) | p = 0,354 |
| Acceleration to HI (m) | p = 0,857 |
| Deceleration to HI (m) | p = 0,717 |
| Metabolic power to HI (m) | p = 0,500 |

necessary. For both types of drill the intensity expressed was greater in the U16 than in the U15. The U16 are probably more ready to endure a certain type of request

**Table VIII.** Percentage differences between drills for variable of internal load. The value is specified in the column For the type of drill that showed the highest value.

| | For training | | |
|---|---|---|---|
| | 4 *vs* 4 > in/out | In/out > 4 *vs* 4 | p |
| RPE (points) | 14% | | p = 0,001 |

**Table IX.** Percentage differences between age groups for the variable of internal load.

| | By age | |
|---|---|---|
| | U16 > U15 | p |
| RPE (points) | 50,4% | p = 0,000 |

**Table X.** significance of the interaction between age group and Drill type for the variable of internal load.

| | Interaction |
|---|---|
| | p |
| RPE (points) | p = 0,008 |

than the U15, as certainly they have got more used to a certain type of intensity, given the diversity of proposals from team coaches used in this study. As for the RPE, the U15 perceived less exertion in both drills. Therefore, the proposal of 4 vs 4 in this age group did not result in obtaining the expected intensity level. This is probably linked to a limit of this preliminary study, that is, to the fact that the U15 involved in this study were not used to performing a drill such as the 4 vs. 4 and as a result failed to express the maximum physical effort.

In reference to the studies conducted to date, it can be noted that there are more similarities with the in/out possession (Capanna), because many drills have used a space of 30 x 20 m in the execution of the SSGs, although with different game time, number of players and repetitions. These studies have shown that the higher the number of players in a predefined space, the lower the intensity, although in our proposal the different ages of the participants influenced the response to stress. In both drills there were no limits to ball touch, another factor that affects the increase of individual internal load. A spur also influences the increase in intensity, as shown by Coutts (10) and Rampinini (2), and the two proposed drills included this kind of stimulus. As for the parameters of external load, the number and intensity of accelerations and decelerations in the two different fields of “double square” drill and even in the in /out were not analyzed.

The difference in RPE may however suggest that these drills are in line with what has been observed by Gaudino et al. (6). Another interesting topic to be developed concerns the analysis of internal and external load in ball drills with game themes and specific rules suitable for the different age groups of the youth sector. Moreover, future studies shall be geared towards an attempt of planning and preparation with respect to ball drills.


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