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Original Research

Effects of direction change in running with and without the ball and performance level on metabolic demands in young basketball players.

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Abstract: Studying several types of running conditions with different tasks is useful to understand how metabolic demands change considering the complexity of the task performed (running with and without the ball). The hypothesis formulated is the following: the strength of the lower limbs may decrease more in the running with ball and between two groups (élite and sub-élite); while the energy expenditure should be different in four running conditions. The sample of subjects included twenty-four young male basketball players between 19±1 years old, divided in two groups (élite n=12 and sub-élite n=12). The aim of this study is to estimate the expenditure metabolic and the level of decreasing strength of the lower limb at different running conditions (two linear running and two shuttle running). The experimental approach required a portable Metabolimeter to assess the metabolic expenditures, Squat Jump (Optojump) to assess the strength of the lower limbs before and after each test. The T-test for independent sample was used and two-way repeated measures ANOVA to assess the significant differences for each running conditions. This study has showed a different metabolic expenditure between two groups: energy consumption is increased when running with the ball compared to when running without the ball and also when changing direction compared to linear running. The results could be useful to coaches to optimize the training load of young basketball players and to improve the motor learning.

Keywords: change of direction, strength, physical fatigue, performance.

1. Introduction

The team sports such as basketball, soccer and rugby, require several types running and therefore imply a different energy demand (Altavilla & Raiola, 2019).

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Basketball is characterized by multiple high-intensity movements (Sanchez-Sanchez et al, 2018) and basketball players must possess specific performances physical qualities for effective game development (D'Elia et al,2021). Typically, running in team sports has either different biomechanical characteristics that different energetic demands (Altavilla, 2020), therefore it is important to understand what differences there are, in terms of strength and energy commitment, running with and without the ball and between élite and sub-élite players. And so, to analyze the several types of runs with different tasks is useful to understand how the metabolic demands change due to the complexity of the task performed (running with and without the ball) and consequently use the necessary workload during workouts. Moreover, it is important to understand fatigue adaptations (Izzo et al, 2020); in this the basketball players must be able to perform specific motor tasks effectively and economically even in conditions of physical fatigue (da Silva Lira et al, 2017; Di Domenico & Raiola, 2021; Kamandulis et al, 2013). The match analysis established that basketball players perform sprint over short distances (10<20m) and within the 20 seconds (Andelkrim et al, 2007; Montgomery et al, 2010), with and without changes of direction, with and without ball and at different velocities (Altavilla et al, 2022); all these variations during the match determine considerable and different metabolic demands (Abdelkrim et al, 2010). The workload analysis during a match is essential today to optimize the training program (Ardigò et al, 2020). Related studies are generally limited to the overall load, in fact few research have investigated on the physiological load of acceleration and deceleration (Petway et al, 2020; Taylor et al, 2017) during different types of running with change of direction by detecting the metabolic cost and the decrement of strength in different running conditions (with and without ball), such as Linear Running (LR) and Shuttle Running (SR) with 180° changes of direction. The analysis of the running conditions can contribute to the improvement of a better performance increasing motor learning process based on a specific motor task and to optimize the training load. The purpose of this study is to value the metabolic expenditure and the changes to explosive strength of lower extremities in four running conditions, with and without the ball: LR and SR with change in direction at 180°, every 15 m, and between two basketball groups (élite and sub-élite). The hypothesis: the metabolic expenditure should be different in four running conditions, between the linear and shuttle running; due to the deceleration/ acceleration of the player on the frontal plane, compared to changes in direction (180°); since player's body stabilization needs more mechanical work. While the strength of the lower limbs may decrease during the running with ball (compared to running without ball) and between the two groups (élite and sub-élite).

2. Materials and Methods

The sample of subjects included twenty-four young male basketball players aged 19±1. Subjects represented two groups (elite n=12 and sub-élite n=12). They had done at least five years of training activity and participated at the Italian basketball championship élite and sub-élite Under-19. All the tests were conducted on a synthetic rubber surface. The convenience method was used to recruit subjects, where subjects are selected due to their convenient accessibility and proximity to the researcher. They had voluntarily participated voluntarily. The experimental procedure was explained before the participation to this study. An informative consent was signed by the subjects' parents or by the legal guardians. The study adhered to the ethical code of the Declaration of Helsinki, and the procedures were in line with established ethical standards in sports sciences (Winter & Maughan, 2009).

Procedures —The variables detected: maximum oxygen consumption $(ml \cdot kg \cdot min^{-1})$; mean and maximum heart rate (b/min); mechanical work ($j \cdot (kg \cdot m)^{-1}$) and Jump performance (cm). The method to detect and to analyze data has required the use of several tests/devices: Yo-Yo endurance test (Bangsbo et al, 2006); LR and SR (Vaquera et al, 2016); Zamparo et al, 2014) assessed with Metabolimeter K4b2; Optojump to assess lower limb muscle strength (Bosco et al, 1983). In table 1 are represented the anthropometric and physiological characteristics of the two groups taken into consideration. The mean age of the first group (élite) was 18.7 ± 0.4 years, the body height was 190.2 ± 3.6 cm, the body weight was 81.4 ± 2.8 kg, while the body mass index was equal to 22.6 ± 3.3 kg/m². The mean VO_2max was 54.2 ± 1.8and the heart rate max 182.6 ± 2.8. The mean age of the second group (sub-élite) was 18.9 ± 0.4 years, their body height was 182.1 ± 2.5 cm, the body weight was 77.3 ± 3.1 kg, while the body mass index was equal to 23.4 ± 3.7 kg/m². The mean VO_2max was 50.5 ± 2.4 and the heart rate max was 184.5 ± 2.6.

Table 1. Anthropometric and physiological characteristics

Variables	Élite (n=12)	Sub-élite (n=12)
Age (years)	18.7 ± 0.4	18.9 ± 0.4
Height (cm)	190.2 ± 3.6	182.1 ± 2.5
Weight (kg)	81.4 ± 2.8	77.3 ± 3.1
BMI (kg/m²)	22.6 ± 3.3	23.4 ± 3.7
VO_2 max ($ml \cdot kg^{-1} \cdot min^{-1}$)	54.2 ± 1.8	50.5 ± 2.4
Heart rate max (b/min)	182.6 ± 2.8	184.5 ± 2.6

The two groups were provided with explanations on the experimental protocol. The study included 5 testing sessions over a 7-day period with a minimum of 2-day rest within the week (table 2). In the first session, the players did an indirect test to determine VO_2max (Léger & Boucher, 1980) to set the intensities for the next sessions of running. Randomly performed two sessions without ball: LR and SR with change of direction (180°) every 15m. The same two sessions, then, were repeated with ball. For each session, at players were required to run at an intensity equal at 80% of VO_2max. It has been used a frequency meter to monitor the intensity. Beep sounds and track markers have been used as spatio-temporal references for the players. In addition, before each test, players performed about 10 minutes of a warm-up (Altavilla et al, 2018a), followed by 5 minutes of dynamic stretching with exercises that affect the lower limbs. We have established five testing sessions over a seven-day period with two days of rest in-between. All tests were repeated after one week, to assess the reliability of measurements. The Yo-Yo endurance test has been performed by each participant, as an incremental test (di Prampero et al, 2009) to detect the VO_2max. Then, the Squat Jump (SJ) has been performed (D'Elia et al, 2020) and, before and after each running conditions, lower muscle limbs strength has been assessed with Optojump. Following, players were tested (speed: 1000m at 80% of VO2max, previously measured) and randomly selected (one-to-one). Each group has been randomly evaluated in four running conditions: LR and SR with change of direction (180°), every 15m, with e without ball.

Table 2. Timetable of testing sessions over a7-day period.

Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Yo-yo Test (is done only this time)	Rest	LR without ball (all day)	LR with ball (all day)	Rest	SR without ball (all day)	SR with ball (all day)	Rest

LR: Linear Running; SR: Shuttle Run.

Statistical analysis —The results are presented as the mean and standard deviation (Mean ± SD). The normality of the data distribution was verified by means of the Shapiro-Wilk test, while the homogeneity of the variances was verified with the Levene test. It has been calculated the intra-class correlation coefficient (Hopkins, 2000) to assess the reliability of the measures for the four running conditions. T-test for independent sample was used to examine the significance of the differences for each running condition (n=4). Instead, the two-way 2×2 between-within ANOVA, for lower limbs strength in each running condition (n = 4), was used to quantify the significance of the effect of the between-subjects factor Group (élite and sub-élite), within-subjects factor Treatment (Pre and Post) together with the factorial interaction Group×Treatment. Finally, the Bonferroni post-hoc correction was applied to identify particular differences and partial eta squared (η2) was used to establish the effect size. The analyses were performed with 95% confidence interval and p≤0.05. The statistical analyses were performed with SPSS Statistics version 23.

3. Results

The results shown in Table 3 demonstrates significant differences regarding both two groups analyzed (élite and sub-élite) for each running conditions, especially in the running condition SR with the ball. The homogeneity of the variance was checked by the use of Levene's test and It has been confirmed for all the different running conditions (n=4).

Table 3. T-test for independent samples: metabolic expenditure for each running condition

Variables	Mean èlite C_$[j \cdot (kg \cdot m)^{-1})]$	Mean amateur C_$[j \cdot (kg \cdot m)^{-1})]$	t-value	df	p	Levene's test F(1,df)	p Levene's test
LR without ball	4.80 ± 0.16	4.98 ± 0.20	-2.77	24	0.01	0.60	0.44
SR without ball	5.21 ± 0.30	5.49 ± 0.27	-2.73	24	0.01	0.45	0.50
LR with ball	5.63 ± 0.23	5.82 ± 0.21	-2.39	24	0.02	0.00	0.92
SR with ball	6.40 ± 0.41	6.80 ± 0.35	-2.86	24	0.00	0.59	0.44

LR= Linear Running; SR= Shuttle Run; C= Energy Expenditure; p= p-value

Table 4 shows the values of Intraclass Correlation Coefficient (ICC), about expenditure metabolic detected after each running conditions in two groups (élite and sub-élite) with and without ball, was found to be excellent. Therefore the detected measures of metabolic expenditure at two different times are reliable.

Table 4. ICC for the reliability of the measures of expenditure metabolic

	Gr. A (élite)		Gr. B (sub-élite)	
LR without ball	ICC	0.98	ICC	0.97
SR without ball	ICC	0.96	ICC	0.95
LR with ball	ICC	0.96	ICC	0.97
SR with ball	ICC	0.97	ICC	0.96

LR= Linear Running; SR= Shuttle Run; ICC= Intraclass Correlation Coefficient

Table 5 shows the effects and interactions between two factors (Treatment-Groups) and the dependent variable (lower limb strength), for the LR and SR (pre and post) and for both groups taken in consideration (élite and sub-élite), estimated through a two-way repeated measures ANOVA. The results, in the different running condition, between the groups they were significant differences, so as in R1 treatments. This why the elite group has high preparation technical and physical (higher values coordination and conditional) than at group sub-elite. While the interaction between the groups and treatments R1*Groups are not significant. Finally, the size of the partial effect in the case of the groups is small, instead in the case of the treatments (R1) they result to be medium-sized. Larger partial eta-squared values indicate a greater amount of variation accounted for by the model effect, values ranging from 0 to 1. The results provide relevant information, contributing to improving performance by intervening on the workload.

Table 5. Effects and interactions between treatment-groups and lower limb strength

	LR without ball		SR without ball		LR with ball		SR with ball	
Effects	P	Partial eta-squared	P	Partial eta-squared	P	Partial eta-squared	P	Partial eta-squared
Groups	0.01	0.18	0.00	0.36	0.01	0.18	0.00	0.36
Treatment	0.00	0.74	0.00	0.52	0.00	0.89	0.00	0.77
Treatment * Groups	0.25	0.04	0.12	0.08	0.32	0.03	0.14	0.08

LR= Linear Running; SR= Shuttle Run; p= p-value

4. Discussion

The strength of the lower limbs has decreased more in the running with ball and between two groups; while the energy expenditure has been different in four running conditions, as claimed in the initial hypothesis. Indeed, the muscular effort and physiological demand in the SR (due at the accelerations and decelerations) result much more energetically expensive compared to LR. A greater significant difference was detected between the two groups analyzed during SR with the ball, as it required greater muscular work (due to the action of the deceleration and acceleration action on each change of direction) and motor control of the ball (Table 3. p = 0.00). The élite group showed a lower energy cost and heart rate values than the sub-élite group in both running conditions with and without the ball. The data obtained in this study offers new information that allows a more accurate estimation of the metabolic demand and strength's decrease of the lower limbs linked to acceleration and deceleration and changes in direction. The values showed in Table 4 of ICC calculated for to verify the reliability of the measures of the metabolic expenditure, for each running conditions in both groups with and without the ball, they have showed a high reliability (0.94 to 0.98). Lower limbs muscle strength was detected before and after each running conditions LR and SR, with and without the ball), in both groups (élite and sub-élite). Through this procedure each player was measured twice for each running condition. The values showed in table 5 indicate the effects and interactions between two factors (Treatment-Groups) and the dependent variable (lower limbs strength). There were significant differences in all running conditions (LR & SR, with and without ball) between the two groups (Groups: 0.01; 0.00; 0.01 and 0.00) and in the treatments (Treatments: 0.00; 0.00; 0.00 and 0.00). Therefore, for each running condition there was a significant difference in lower limbs strength decrease both the two groups and before and after the tests for each group. Instead, the interactions between the groups and the treatment (Treatment*Groups) were not significant for the running conditions considered (p: 0.25; 0.12; 0.32; 0.14). The metabolic expenditure is clearly increasing in relation to the increase in speed and it is as shorter the shuttle path (Buglione & di Prampero, 2013) since the cost of decelerations and accelerations imposes greater physiological demands on players than linear running at constant speed. Furthermore, the different metabolic cost between the two groups (élite and sub-élite) increases even more during running with the ball to running without the ball. This is due to an additional requirement necessary for the motor control of the ball with the different running conditions (this additional expense is less in elite players because they are more capable and skillful compared to sub-élite players). The evaluation, training and continuous monitoring of the physiological aspects and conditional skills, become an important aspect for the control of the performance (Altavilla et al, 2018b) and the possibility of identifying new talents (Junior et al, 2021). The study has some limitations, such as the number of players chosen, due to the availability of the clubs. A second limitation could be the choice to investigate linear running which however is still present in counterattack actions, even if in a more limited way compared to running with changes of direction.

5. Practical Applications.

The practical application could be limited to the tactical aspect of ball control (less dribbling and more passing) and the technical care in teaching the quality of movements without the ball (effectively get away from own opponent). According to the results acquired in the different running conditions, there is an even greater need to use specific exercises during training (exercises very similar to the actions performed during the match) with the purpose of improving the performance of basketball players, such as the energy cost, VO_2max, the ability to sustain workloads and high intensity in a prolonged manner, with frequent changes of direction and with short recovery periods.

6. Conclusions

This study has confirmed initial hypothesis, showing a different metabolic expenditure in the four running conditions (LR & SR with and without ball) and between the two groups (élite and sub-élite). In addition, it has confirmed also with regard to the decrease in lower limb strength, there was a significant difference between the group and in treatments. In fact, the results indicate that the energy expenditure in the SR is greater than for the LR, as well as in the running with ball than at the running without the ball; and it is also greater for the sub-élite group than élite group. An effective drill that can be used during training is an intermittent work, created by shuttles with short recovery times, accelerations and decelerations, with speed’s variations, with and without changes of direction, with and without dribble. Finally, it is possible to intervene on load variables, modifying time, speed, repetitions, distance, recovery and the sequence and type of technical movements; thus improving the conditioning and motor control aspects.

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Conflicts of Interest: The authors declare no conflict of interest.

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