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Influence of various preseason training in elite youth soccer players

Research Article

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Abstract: Aim: Endurance capacity of each individual soccer player can notably influence a team's success. The opinion about the necessity of generic endurance specific training in soccer, especially in adolescent athletes, still varies widely. Methods: We examined n = 38 elite premier league youth soccer players from three different age groups and with a different amount of endurance specific training. Two identical graded incremental exercise tests were performed before and after a 5 weeks training intervention. Besides soccer specific training, the different groups absolved either 25 - 30% (U16 and U19) or < 5% (U17) of generic endurance specific training as well as soccer specific endurance training. After the training intervention the alterations of blood lactate concentration (La-), the individual anaerobic threshold (LT) as well as the 4 mmol/-1 threshold were determined. Results: Running velocity of the U16 and U19 players at individual anaerobic threshold and at the 4 mmol/-1 threshold increased significantly. In contrast, no changes of the LT or 4 mmol/-1 threshold could be detected for the U17 players. Conclusions: The individual endurance capacity of young elite soccer players can be improved significantly, even over a short preseason period, by performing an adequate amount of generic endurance specific training.

Keywords: *Aerobic exercise • Anaerobic threshold • Athletes • Exercise testing • Adolescent*

1. Introduction

In modern soccer, aerobic endurance capacity of the individual players is of relevant importance for a team's success [1,2]. Due to the size of a soccer field, single players are required to run comparably long distances. Wisloff et al. [2], for example, showed a significant correlation between aerobic endurance capacity and running distance during a soccer game. Depending on the position, players are reported to run a total distance of between 10 and 12 kilometres during a complete game of 90 minutes [3-5].

Furthermore, it is known that the aerobic system contributes 90% of the total energy cost of match play [6,7], whereas the players also experience single match situations or even periods of high intensity in which accumulation of lactate takes place [4,7,8]. Thus, the players need periods of low-intensity aerobic activity to remove lactate from the working muscles while still participating in the game.

Consequently, a higher anaerobic threshold theoretically leads to a higher amount of mean intensity capacity of a single player without the consequence of lactate accumulation [7]. In fact, several studies have shown a remarkable influence of aerobic fitness on tactical performance, tactical choices [7,9] and injury incidence due to fatigue, the latter especially during the second half of a game [10]. It has even been described that improved endurance capacity in each team player may be reflected in an additional, "virtual", twelfth player [4].

As generally known, submaximal blood lactate assessment is a useful tool for detecting changes in endurance fitness of soccer players [6,11,12]. Some authors even describe determining lactate threshold to possibly

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be a more sensitive indicator of aerobic endurance performance than determining maximum oxygen uptake ($VO_{2\ max}$) [13-16].

Either way, the endurance level of the player is of major interest to soccer coaches, fitness coaches and last but not least the player himself [9]. Even more interesting to all team responsibles and so far continuously debated are the tools and training characteristics that influence aerobic capacity, ideally without influencing the players other soccer specific capacities, e.g. sprinting, dribbling etc.

So far researcher's interest mainly focussed on the endurance capacity effects of generic aerobic training versus soccer specific training [7,16]. Beyond this, the variability of soccer experts' opinions about endurance specific training is of particular interest concerning the physical development of adolescent soccer athletes in their development to become professionals. Various studies accentuate the importance of adequate training stimuli, especially in young soccer players [17,18], in order to develop further elementary physical capacities on their career path.

Therefore, the aim of this study was to evaluate the relevance of different amounts of generic endurance specific training in different aged professional youth elite soccer players during a regular preseason period of 5 weeks.

2. Methods

We used a three groups, partially group matched, longitudinal (pretest - posttest) design. As soccer specific endurance or match performance was not investigated, the individuals within the groups were not matched according to their playing position. Due to separate training with different training aspects goalkeepers were excluded from the study.

2.1 Participants

Over a preseason period of 5 weeks we examined 38 healthy elite premier league youth soccer players from three different age groups: under 16 years (U16, n=11), under 17 years (U17, n=12) and under 19 years (U19, n=15). Each individual had been regularly training at least 8 hours/week over the past two years as well as at least 8.66 hours/week (8.66 to 12.0 hrs.) during the complete training intervention. All players underwent a standardized exercise testing to determine their lactate threshold before and after the different training interventions (see below). Players that needed to refrain from training longer than one day were excluded from the study. The study meets the Principles of the Declaration of Helsinki [19] as well as the university's Ethics Committee approved the project. According to the guidelines of the university's Ethics Committee, the athletes were thoroughly briefed about the planned exercise tests. Furthermore all participants signed an informed consent to participate in the collection of data.

2.2 Exercise protocol

All individuals completed a graded incremental exercise running test (IET) on an outdoor track. The IET followed a documented standard protocol [20,21], starting with a speed of 6 km/h (1,67 m/s) for 3 minutes and increasing the speed in steps of 2 km/h (0,55 m/s) for three minutes, each until complete exhaustion (Figure 1). The correct and constant speed at each stage was controlled by a cyclist ahead of the running subjects using a calibrated digital tachymeter. One test was performed right before the beginning of the preseason training followed by an identical test at the end of the preseason phase. Both exercise tests were performed at the same time of day as well as under similar weather conditions.

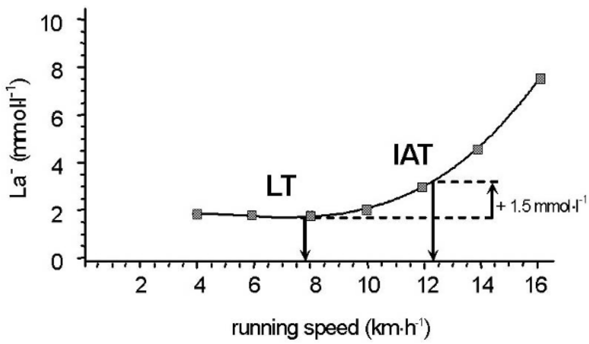

Figure 1. Determination of the aerobic threshold (LT) and the individual anaerobic threshold (IAT).

2.3 Training protocols

During the entire training phase the coaches of the three teams documented their training sequences daily. This documentation included the complete duration of the separate training sessions as well as the differentiation of the training characteristics and their particular duration. The characterisation of a training unit followed a predetermined scheme (Table 1) whereat the different aspects of generic endurance training (e.g. endurance running, 6 x 1000 m etc.) were not documented separately. Players controlled the previously given training intensities by pulse watches. At the end of the preseason training phase, the different training characteristics were summarized and analysed separately for each team.

2.4 Determination of IAT and v-4mM

The blood lactate concentration (La-) was determined using an enzymatic electrode method (ESAT, Eppen-

Table 1. Predetermined scheme in order to characterise different training aspects.

Warm up/ Regeneration	- Gymnastics - Warm up and regeneration running (maximum 20 min., < 75% of maxHR) - Stretching
Endurance training	- Generic endurance specific training respecting the players individual lactate threshold (endurance running 75 – 85% maxHR, 4x4 minutes interval training 90 – 95% max HR, 6 x 1000 m intensity 90 – 95% maxHR etc.)
Technical training, Coordination training	- Dribbling - technical performance - Hurdle jumps - Drop jumps - Passing - Shooting, etc.
Small sided games	- 5 vs. 2 (2 centre players, 5 surrounding players, one touch of surrounding players, centre players against the ball), 90 – 95%, maxHR, duration 20 minutes, short interruptions by player changes - 7 vs. 3 (3 centre players, 7 surrounding players, see above)
Strength training	- Weight lifting - Leg press - Leg curls - Training of upper body, etc.
Games	- 6 vs. 6 with goalkeeper (2-3 ball touches, 20 minutes, ½ field) - 8 vs. 8 with goalkeeper (2-3 ball touches, 20 minutes, 2/3 field) - 10 vs. 10 with goalkeeper (free ball touches, 20 -30 minutes, complete field) - Training matches against other teams (2x40minutes (U16 + U17), 2x45 minutes (U19) complete field)

dorff, Hamburg, Germany). The time course of La- was graphically interpolated using an equalizing spline procedure (Roecker, Schotte, Niess, Horstmann & Dickhuth, 1998; Roecker, Striegel, Freund & Dickhuth, 1994). The lactate threshold (LT) was defined as the lowest value of the quotient $[(La\text{-})\cdot(km\cdot h^{-1})^{-1}]$. The so-called individual anaerobic threshold (IAT) was defined as the running speed at LT + 1.5 $mmol\cdot l^{-1}$ La-. The graphical and numerical evaluation of the lactate parameters was done independently by the examiner using a software written for performance diagnostics (AIMS, Tuebingen, Germany). Running velocity at a lactate concentration of 4 $mmol/^{-1}$ (v-4mM) was calculated by linear exploration.

2.5 Test-retest reproducibility

During incremental treadmill running, reproducibility of determining lactate threshold or IAT is described to be r=0.9 (p<0.01) or r=0.97 (p<0.01) respectively [20]. Furthermore, although slightly differing in performance, outdoor field methods to obtain cardiorespiratory and metabolic data are found to be valid tests in comparison to laboratory tests [24]. Internal controls in order to evaluate the validity of the described field exercise test in comparison to a treadmill test revealed a correlation coeffizient of 0.89 in 10 subjects.

2.6 Statistics

The raw data for the total amount of each training characteristic were measured in the three different groups. The data were then processed and analysed by the statistics program JUMP (SAS Institute, Cary, USA). Running velocities at IAT and v-4mM did not show signs of non-normal distribution when using the Wilk-Shapiro W-test. The experimental setting and data therefore allowed comparisons of the individual preseason training data with the data after the 5 week training period by paired Student's t-test.

3. Results

Mean age (standard deviation) of the players U16 was 15.0 years (±0.5), whereas the U17 player's age was 16.2 yrs.(±0.4) and the U19 player's age 17.3 yrs. (±0.6) respectively. At the time of the investigation the mean player's height was 174 cm (7.9) for the athletes U16, 179,4 cm (3.6) for the players U17 and 180,7 cm (8.0) for the participants U19. Mean body weight U16 revealed 63.6 Kg (9.0), 72.2 Kg (2.9) for the group U17 and 73.1 (7.0) for the participants U19. The anthropometric data are shown in Table 2.

Table 2. Anthropometric data of players (n = 38). Values are mean (SD).

	U16 (n = 12)	U17 (n = 11)	U19 (n = 15)
Age [years]	15.0 (0.5)	16.2 (0.4)	17.3 (0.6)
Height [cm]	174.5 (7.9)	179.4 (3.6)	180.7 (8.0)
Mass [kg]	63.6 (9.0)	72.2 (2.9)	73.1 (7.0)
BMI [$kg \cdot m^2$]	20.8 (1.9)	22.4 (1.0)	22.3 (1.1)

Generally, the training documentation of the individual teams revealed an increasing amount of total training time according to the increasing age of the players. Total training hours of the players under 16 years averaged 8.66 hours, whereas the elder players trained 9.58 hours/week (U17) on average or 12 hours/week (U19) respectively. Due to the preferences of the individual coaches, the amount of the different soccer specific training characteristics varied slightly between the different age groups. The only remarkable and predetermined difference in training design was a comparably low proportion (0.33 hrs./week = 3.4%) of generic endurance specific training in the U 17 group in relation to the other age groups (U16, 2.33 hrs/week = 26.9%; U19, 3 hrs/week = 25%) (See Table 3). Furthermore, training documentation of the U 19 group revealed a lower amount of small sided games (13,9% vs. 26,9% (U16) and 31,3% (U17)).

Over the entire preseason intervention, the mean running velocity of the group U16 at the IAT increased

Table 3. Overview of average soccer training hours per week (hrs.(percentage) in the different age groups following a predetermined scheme in order to characterise the different training aspects.

	U16 (n = 12)	U17 (n = 11)	U19 (n = 15)
Warm up/ Regeneration	1.5 (17,3%)	1,75 (18,3%)	2 (16,6%)
Endurance training	2.33 (26,9%)	0,33 (3,4%)	3 (25,0%)
Technical training, Koord	1 (11,5%)	2 (20,8%)	2.5 (20,8%)
Small sided games	2.33 (26,9%)	3 (31,3%)	1.67 (13,9%)
Strength training	0.5 (5,7%)	1 (10,4%)	1.33 (11,0%)
games	1 (11,5%)	1.5 (15,66%)	1.5 (12,5%)
total	8.66	9,58	12.0 (12,5%)

by 0.92 km/h from 13.38±1.01 km/h to 14.3±1.03 km/h ($p < 0.001$). Similarly, running velocities at V-4mM increased significantly by 1.05 km/h (preseason 14.91±0.99km/h vs. post intervention 15.96±1.11 km/h; $p < 0.001$). The single values are shown in Figure 2.

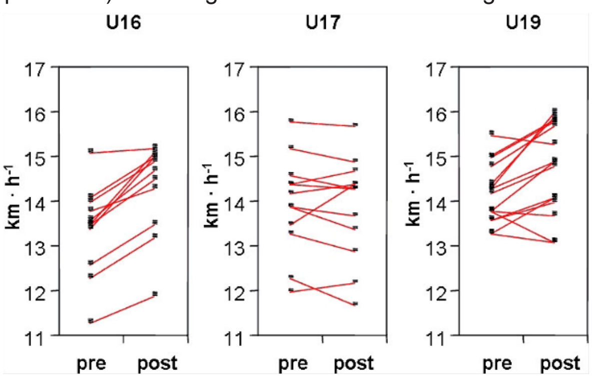

Figure 2. Diagram of the single values at the IAT for the three different age groups U16, U17 und U19 before and after a 5 weeks preseason training phase.

Comparably, the running speed of group U19 during the preseason period could be improved at the IAT by 0.57 km/h (14.18±0.67 km/h to 14.75±1.01 km/h ($p < 0.01$)) and the v-4mM by 0.52 km/h (15.99 ± 0.92 to 16.51±1.22 ($p < 0.01$).

However, the group U17 did not improve their endurance performance showing almost unaltered test results at IAT (13.96±1.09 km/h before preseason phase vs. 13.88±1.16 km/h after the preseason intervention (non significant) and for v-4mM (15.67±1.10 km/h vs. 15.82±0.98 km/h; n.s.), respectively.

No significant differences in lactate responses could be detected when plotting the lactate against running velocities at the two different testing points (Figure 3).

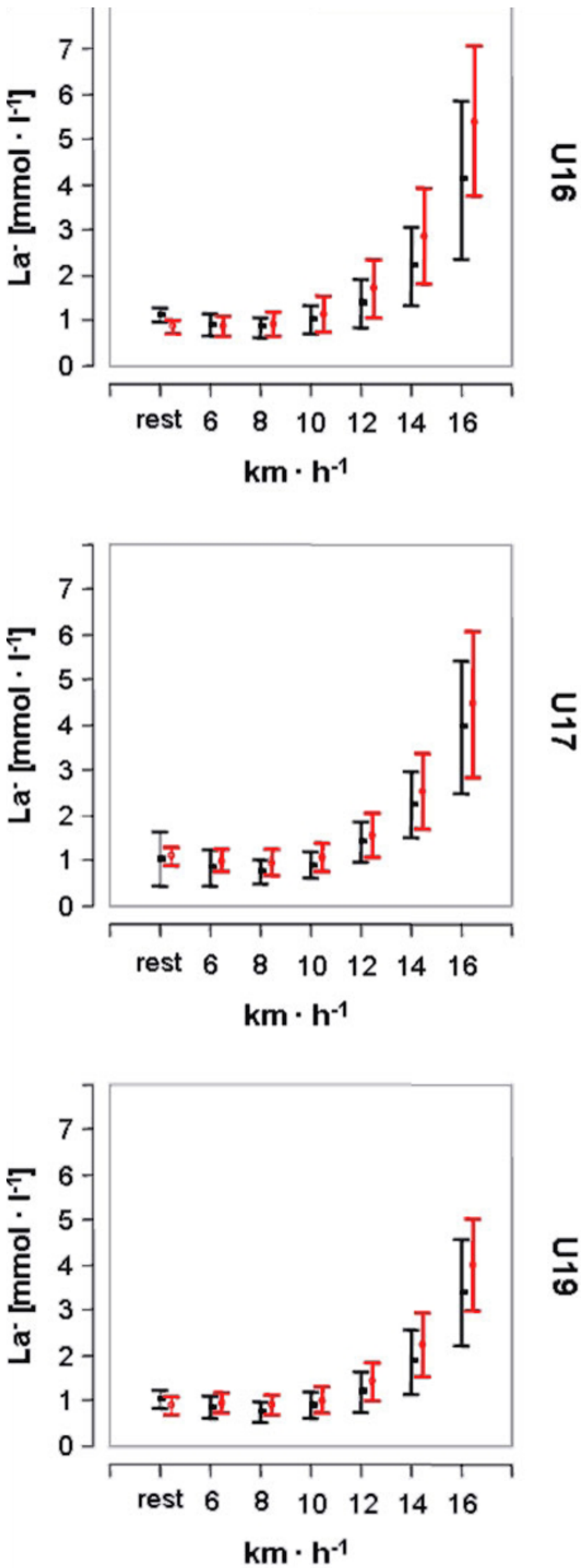

Figure 3. Lactate levels at fixed running velocities for the three groups U16, U17 und U19 before (■) and after (●) a 5 weeks preseason trainig phase (means and SD).

4. Discussion

High professional modern soccer sports requires a reasonable amount of endurance capacity of each individual player in order to realise different tactical systems, deflect the game appropriately or, last but not least, vary its velocity. Numerous studies have proven the dependency of endurance capacity and total running distance, amount of sprints per game or amount of ball contacts [25], all of which are requirements for a successful soccer match. Especially in adolescent players with a perspective to become professionals, their further career path and subsequently their performance in premier league or national teams significantly depends on their endurance fitness. Last but not least, due to fatigue, the injury incidence across a soccer match is known to increase towards the end of each half [26], which even more prescinds the necessity of an adequate fitness level. Thus, notably because the off season period is normally quite brief, optimal and age adapted endurance training for youth soccer players seems to be an inevitable necessity and is often claimed [18].

Our study clearly showed a significant increase of a youth soccer player's endurance capacity due to adequate generic, endurance specific training even over a brief preseason training period of five weeks. As several authors revealed comparable benefits of generic or soccer specific endurance specific training [7,16], the benefit itself might have been predictable, though in comparison, training interventions of these studies were at least 8 weeks or longer. Consequently, in these studies the brief preseason period was not investigated in particular but evaluated across the complete training intervention. For example, Impelllizzeri et al. [16] described the most notable effects of generic or specific endurance training during the first 4 weeks of a 18 weeks intervention period.

Anyhow, such a clear increase could not necessarily be expected, as a training period of 5 weeks is normally considered to be quite brief to achieve significant results. For example, in pure endurance sports (middle distance runners), Striegel et al. [27] found an improvement of "only" 0.52 km/h after a season break and a subsequently longer basic training period of 12 weeks which even consisted of a major amount of specific, basic endurance training (>80%). Of course, the endurance fitness level of well trained middle distance runners and their perequisits for further improvements may not be completely comparable to soccer players. Nevertheless, it reflects the necessity of a particular duration of highly specific endurance training in order to achieve notable results in professional athletes.

Based on the running velocity at the lactate threshold as well as at the level of v-4mM lactate, Mc Millan et al. [11] also demonstrated a significant increase of endurance capacity (1.29 km/h (LT); 1.05 km/h (v-4mM)) of british youth soccer players. His subjects were initially tested at the beginning of the preseason phase after the summer intermission and retested at six time points throughout a soccer season. However, due to the longer intervention period, the study could neither clearly show how much or which aspect of the endurance capacity in particular was due to the brief preseason period, nor could it reveal the relevance of different training characteristics. In a summarizing review, Bangsbo et al. [6] likewise described significantly lower lactate concentrations during submaximal running after a 5 weeks preseason period as well as Brady et al. [12] detected an improved aerobic endurance performance over the preseason preparation of an elite Scottish soccer team across two soccer seasons, whereas the importance of different training aspects in this preseason period was not investigated in either study. Dunbar et al. [28] however could not find any improvements of fixed lactate concentrations over the preseason period of English professional players.

In contrast, our study clearly showed an improvement of basic endurance capacity during a 5-week-preseason intervention as a consequence of an increased amount of several forms of generic endurance specific training. Of course, compared to similar studies [7,16,29], our study does neither allow an exact conclusion concerning the benefit of each singular form of generic endurance training (endurance running, 6x1000 m etc.), nor does it reveal a conclusion concerning the difference between the benefit of generic versus soccer specific training.

Furthermore, it could be argued that the improvement of aerobic and anaerobic endurance capacity in this study is a result of normal growth development in precreational youth athletes [18]. Nevertheless, as only two of the three investigated groups (U16 and U19) showed an alteration other than the group of the players under 17 as well as the group U 19 showed an improvement though a smaller amount of small sided games, we concluded that these improvements was most notably a consequence of the generic endurance specific training (U16 and U19).

A change of the individual endurance capacity can also be illustrated by the relation between lactate figures and fixed running velocities [11]. In our study, the lacate threshold after the preseason training phase did not show a significant alteration of this relation. These results are congruent to the findings of [7], who also did not find alterations at the lactate threshold in soccer players despite a significant increase of Vo2max after a 8 week training intervention.

To what extent endurance training negatively influences other necessary physical aspects (especially sprinting and coordinative skills) is unclear. Mc Millan et al. [11]

for example demonstrated improved $VO_{2\ max}$ in professional youth soccer players after 10 weeks of high intensity aerobic interval training using a soccer specific ball dribbling track. They did not find any accompanying negative side effects on strength, sprint capacity or bounce as well as neither Helgerud et al. [7] nor Impellizzeri et al. [16] described any negative side effects on soccer specific capacities as an accompaniment of generic or soccer specific endurance training. In contrast, performing highly intensive interval training, Dupont et al. [30] showed a significant increase of endurance capacity accompanied by a significant decline of sprint capacity over 40 m.

Consequently, recent studies estimated soccer specific training like small sided games to be at least equivalent [7,16] in comparison to generic endurance running. Regardless of the necessity of a high amount of soccer specific training, to our opinion we regard generic endurance running to be a simple and important training method before a season during the summer intermission to prevent a loss of fitness without a high impact on the musculoskeletal system as well as during preseason training periods. The exigence herefore is exemplary reflected in a comparative, retrospective study concerning the effects of the summer rest periods in young amateur players. Amigo et al. [31] describe a significant decrement of the cross sectional area of fast and slow twitch muscle fibres, as well as a decrement of the activity of aerobic enzymes which supports the necessity of well dosed generic endurance specific training even during the summer intermission.

5. Conclusion

Soccer represents an aerobic team sport for the most part [32-34], though anaerobic energy supply plays an important role in intensive game situations, sprinting and ball duels [8].

In conclusion, our study shows that the individual endurance capacity of young professional soccer players is not an accompaniment of normal growth development but can be improved within a few weeks of preseason training by even slightly increasing the amount of generic endurance specific training. Although some authors could show that soccer specific training like small sided games may be equivalent [16] or even better [7] in comparison to generic endurance running, we regard a certain amount of endurance running to be a simple training method that can be added to soccer specific training without a comparably high impact on the musculoskeletal system. Consequently, besides a high amount of soccer specific training and matches, repeated aerobic endurance training phases during a soccer season may furthermore conserve or even improve a player's endurance capacity [30,35] or even prevent an increasing amount of overuse injuries of the musculoskeletal system due to fatigue. On one hand, the effect of specified endurance training seems clear, although, on the other hand, the influence on other soccer specific physical aspects remains unclear. So far – especially in youth soccer players at the beginning of their career path – generic endurance training is an inevitable component of preseason periods.

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