Ten minutes endurance test at 50% upper body weight: a pilot study in healthy controls and physically active people

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Research note

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Abstract

Objective

Intense endurance and strength training mark virtually opposite parts of basic motor skills. Extreme high load physical demands are getting sparer but endurance demands are still present. Therefore, healthy controls and endurance and strength trained athletes at competition level were exposed to a submaximal endurance test of their back muscles.

In this pilot study 38 healthy male subjects participated: physically inactive controls (C, n=12), endurance trained (ET, n=13), and strength trained subjects (ST, n=13). All participants were asked to finish a ten minutes back muscle endurance test at 50% of their upper body weight.

Results

Maximum holding times were shortest in the ST group (469 ± 142 s; ET 600 ± 0 s; C 600 ± 0 s), but statistical significance could only be proven for ET vs. ST ($p < 0.01$). Hedges g's values for comparisons of maximum holding times showed relevant differences among all groups: ET vs. ST 10.64; ET vs. C 2.38; ST vs. C 0.78. Values of perceived exertion increased over time with lowest values for the ET group, except after the first minute. Especially between 180s and 420s ST group showed highest exertion values, but between group differences could not be determined.

Introduction

To counteract today's inactive lifestyle, recreational sports is becoming increasingly popular, since positive effects on metabolic processes [1], or more generally life satisfaction especially in old age [2] can be identified to name just two examples. Nowadays, there is a wide range of possibilities, whereby every physical activity can ultimately be traced back to the basic motor skills strength, endurance, speed, agility and coordination. Depending on the chosen training modality, the respective training focus is either on several aspects at the same time or individual aspects are particularly emphasized. In particular, strength and endurance are possible isolated individual training goals, while speed, agility and coordination can be regarded as a prerequisite for any type of sports activity in terms of training progress and protection against injury. However, the maintenance or training of these basic skills plays a role not only for athletic activity, but also for everyday life. Here we must react appropriately to a wide variety of physical demands. Since extreme strength requirements in everyday life are becoming sparer, endurance training in particular represents an essential part of everyday physical demands. The impact of extreme training intensities of endurance and strength training was therefore investigated in the present pilot study. For this investigation inactive control subjects as well as endurance and strength athletes were exposed to a ten-minute endurance test of their back muscles at 50% of their upper body weight.

Methods

For this pilot study we recruited 38 healthy male participants. Participants consisted of three subgroups: a group of physically inactive people (Control (C), n = 12) and two groups of physically active people at competition level (at least four training sessions per week). The two physically active groups practised either endurance (ET, cycling and triathlon, n = 13) or strength training (ST, power lifting, n = 13). Participants were informed about the procedure and aim of the study and signed informed consent to voluntary participate in this investigation. The study was approved by the ethics committee of the Friedrich-Schiller University Jena (2020-1844-BO). Details about the study participants are provided in Table 1.

Table 1
Participant characteristics

	Endurance	Strength	Control
Age [years]	22.2 ± 2.9	23.5 ± 1.8	22.1 ± 1.0
Height [cm]	184 ± 6.5	180 ± 5.6	184 ± 5.9
Weight [kg]	72.8 ± 7.0	90.3 ± 13.9 §§	78.9 ± 14.3
BMI [kg/m ²]	21.5 ± 1.3	27.7 ± 3.8 §§	23.1 ± 3.8 \$
UBW [kg]	31.7 ± 2.8	37.0 ± 4.5 \$	32.7 ± 4.5
UBT [Nm]	123 ± 12.3	134 ± 21.8	125 ± 19.5
BMI: body mass index; UBW: upper body weight; UBT: upper body torque			

§ p < 0.05 vs. endurance; §§ p < 0.01 vs. endurance; \$ p < 0.05 vs. strength

Standing in upright posture participants were positioned in a computerized test and training device (CTT Centaur, BfMC, Leipzig, Germany). In this device the subjects' lower body is fixed while the upper body maintains freedom of movement. The device is equipped with a harness, positioned over the subjects' shoulder that contains strain gauges for force measurement in frontal and sagittal directions. Additionally the device is equipped with a small feedback monitor in front of the subject. Here a moving target point is displayed that is located in the centre of a crosshair if not net force acts on the harness, i.e. the subject maintains upright body posture. By tilting the device up to horizontal position gravitational forces act on the trunk, enabling defined load levels up to 100% of the subject's upper body weight (UBW). For warm up participants completed a set of submaximal flexion and extension tests. Subsequently they were exposed to 50% UBW extension load by tilting them forward at an angle of 30°. For this endurance test a maximum of 600 s was defined as the target time. Participants were requested to maintain their upright position until target time was reached, or until exhaustion. After every completed minute they were asked about their level of perceived exertion by using the Borg scale [3].

To test differences of maximum holding times among groups basically t-tests were applied, together with the respective Bonferroni-correction for multiple testing. In addition, effect sizes were calculated to address relevance of differences. For this we used Hedges g s as it is particularly suited for small sample sizes [4]. To assess differences of the Borg values between groups the non-parametric Kruskal and Wallis test was applied, followed by the respective post hoc tests.

Results

Maximum holding times were shortest for ST (Fig. 1), but showed significant differences only for ET vs. ST ($p < 0.01$). Anyhow, Hedges g s values showed relevant differences among all groups: ET vs. ST 10.64; ET vs. C 2.38; ST vs. C 0.78. Values of perceived exertion increased over time with lowest values for the ET group, except after 60 s (Fig. 2). Especially between 180s and 420s ST group showed highest exertion values. Although the non-parametric Kruskal-Wallis H test showed significant differences among the groups at 180, 240, 300, 420, and 600 s post hoc tests failed to verify significant group differences.

Discussion

The study revealed a clear advantage of endurance trained but also untrained subjects over strength trained athletes with respect to their back muscle endurance capacity at 50% UBW force level. Further, all athletes were highly competitive, thus any premature termination of the endurance task can be excluded with high certainty. Thus, the absolute as well as relative strength level of back muscles seems to be rather inversely correlated with endurance performance. The lower limit, i.e. values for persons with an even lower strength reserve, could not be determined on basis of the available data. Anyhow, it can be assumed that back muscles endurance performance follows a U-shaped curve, i.e. deficits in endurance performance are expected to be observed in persons with low strength reserve as well. There are indirect indications for this assumption, since values of perceived exertion were always lowest in the ET group, whereas the control group showed highest values after 480 s endurance time, unfortunately without statistical prove. However, the Borg values of the control group may also be caused by lack of experience with respect to physical exertion in general. This is particularly evident for the value after 60 s, where the control group tended to have the lowest values with a mean value of 9, while the two groups of athletes each reported values of 10. Here it would make sense to carry out a repeated examination shortly after this initial examination to test whether the assessment of perceived exertion changes.

We did not take muscle biopsies here but it can be expected that back muscles fibre composition between the two competitive athlete groups differed significantly [5, 6, 7]. For the ST group a largely higher proportion of Type II fibres can be assumed in comparison with the ET group and also larger fibre diameters [8], resulting in early use of Type II fibres and reduced metabolic supply due to the enlarged fibre diameters.

Limitations

- Only few subjects were investigated, therefore the results are preliminary
- Premature termination due to motivational reasons cannot completely be excluded
- Results were gathered during a defined, but artificial test situation, therefore the results cannot be transferred directly to everyday endurance tasks

Abbreviations

Unabbreviated term	abbreviation
Control	C
Endurance trained	ET
Strength trained	ST
Body mass index	BMI
Upper body weight	UBW
Upper body torque	UBT

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of the Friedrich-Schiller-University Jena. The committee's reference number is 2020-1844-BO. Prior to study participation all participants were informed about the purpose and course of the study and signed an informed consent form.

Consent for publication

Not applicable.

Availability of data and materials

The dataset supporting the conclusions of this article is included in an additional supplementary datafile.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CA made substantial contributions to the conception and design of the work, acquisition, analysis, interpretation of data, has drafted the work, approved the submitted version, and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

TS made substantial contributions to acquisition, analysis, interpretation of data, approved the submitted version, and has agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Figures

Figure 1

Maximum endurance times (upper panel) and remaining subjects (lower panel) for the endurance task. Values are given as mean values ± SD. Statistical differences are indicated.

Figure 2

Borg scale values during the endurance task. Values are given as median values $\pm$ quartiles. No statistical differences could be detected between groups.

Supplementary Files

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- [studydatabackmuscleendurance.xlsx](#)