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Title: Physiological factors of importance for load carriage in experienced and inexperienced men and women.

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Structured Summary

Introduction

The ability to carry heavy loads is an important and necessary task during numerous outdoor activities and especially in military operations. The aim of this study was to investigate factors associated with load carrying ability in men and women with and without extensive load carrying experience.

Materials and Methods

The energy expenditure during carrying no load, 20, 35 and 50 kg at two walking speeds, 3 and 5 km h^{-1}, was studied in 36 healthy participants, 19 men (30 ± 6 years, 82.5 ± 7.0 kg) and 17 women (29 ± 6 years, 66.1 ± 8.9 kg), experienced (> 5 years) in carrying heavy loads (n=16, 8 women) or with minor or no such experience (n=20, 9 women). A standard backpack filled with weights to according carry load was used during the walks. Anthropometric data, leg muscle strength, as well as trunk muscle endurance and muscle fiber distribution of the thigh, were also obtained. Extra Load Index (ELI), the oxygen uptake (VO_2) during total load over unloaded walking – was used as a proxy for load carrying ability at 20, 35 and 50 kg (ELI20, ELI35 and ELI50 respectively). In addition to analyzing factors of importance for the ELI values, we also conducted mediator analyses using sex and long-term carrying experience as causal variables for ELI as the outcome value.

The study was approved by the Regional Ethics Committee in Stockholm, Sweden.

Results

For the lowest load (20 kg), ELI20, was correlated with body mass but no other factors. Walking with 35 and 50 kg load at 5 km h^{-1} body mass, body height, leg muscle strength and absolute VO_2max were correlated, while relative VO_2max, trunk muscle endurance and leg muscle fiber distribution were not correlated to ELI35 and ELI50.

ELI50 at 5 km h^{-1} differed between the sexes. This difference was only mediated by the difference in body mass. Neither muscle fiber distribution, leg muscle strength, trunk muscle endurance and body height nor did absolute or relative VO_2max explain the difference.

Participants with long term experience of heavy load carrying had significant lower ELI20 and ELI50 values than those with minor or non-experience, but none of the above studied factors could explain this difference.

Conclusion

The study showed that body mass, without sex differences, and experience of carrying heavy loads are the dominant factors for the ability to carry heavy loads. Even though the effect of experience alludes to the need for extensive carrying training, no causality can be proven. Load carry training intervention studies is suggested for future investigations.

Introduction

Carrying heavy loads is an important and necessary task during many outdoor physical activities, especially military operations. Numerous studies have analyzed the physiological and biomechanical consequences of different loads and speeds. Most of them have shown that energy cost of walking increases progressively with both carry load and walking speed.[1–5] Workloads up to 47 % of maximal oxygen uptake (VO_2max) has been suggested [5], but also lower workloads have been proposed, stating that the highest combination of load and speed acceptable for any individual should be taxing the oxygen transport system to less than 40 % of VO_2max, *i.e.* 35 kg at 3,5 km h^{-1} and 20 kg at 4,5 km h^{-1}.[6,7] However, in many real-life situations, the load-speed combination exceeds that workload limit.

There are previously reported sex differences in load carriage performance.[8] Women experience higher average strain on oxygen transport system and higher perceived exertion than men given the same workload. This can be explained by women having generally lower body mass and lesser absolute VO_2max (l min^{-1}) compared to men.[9] However, other factors of importance for load carrying ability in women and men with equal body mass or the same relative VO_2max (ml min^{-1} kg^{-1}), have not been evaluated. Since studies on women and load carriage is somewhat limited, and women are increasingly entering military occupations, more studies on women and load carriage is warranted. Furthermore, long-term experience of carrying heavy loads is evidently of importance. Sherpas and Tibetan Highlanders can carry loads > 100 % of body mass during long walks. This remarkable carrying ability can partly be explained by the high mechanical efficiency due to better load balancing than in corresponding control subjects.[4,10,11] To the best of our knowledge, several other factors that might be involved in load carrying analyses have not been studied.

The aim of this study was to investigate factors associated with load carrying ability in men and women with and without extensive load carrying experience. Therefore, participants with both long term experience and those with minor experience of load carrying were studied during walking at two normal speeds (3 and 5 km h^{-1}), carrying different loads (20, 35 and 50 kg). Oxygen uptake (VO_2), anthropometric data, leg muscle strength as well as trunk muscle endurance and muscle fiber distribution of the thigh were obtained. In addition, we compared VO_2 during load walking with VO_2 during no load walking at the two different speeds. Thus, a quotient of VO_2 during total load over no load walking, Extra Load Index (ELI), could be calculated. This quotient is accepted as a proxy for load carrying capacity.[12,13] Furthermore, in addition to analyzing factors of importance for the carrying ability (ELI values) we also conducted mediator analyses using sex and long-term carrying experience as causal variables for ELI as the outcome value.

Materials and Methods

Participants

Thirty-six volunteers, 19 men (30 ± 6 years, 82.5 ± 7.0 kg) and 17 women (29 ± 6 years, 66.1 ± 8.9 kg), provided written informed consent to participate in the study after being verbally informed. Inclusion criteria were healthy status with no current or past injury that could compromise participation. Body height and body mass were measured at the initiation of each experiment day using standardized methods to the nearest 0.1 cm and 0.1 kg, respectively. For anthropometric and physiological data – see Table 1. Half of the participants were recruited from firefighters, military personnel and Special Force Police officers, and the other half from The Swedish School of Sport and Health Sciences, Stockholm, Sweden. Participants consisted of people with long term experience (>5 years) of carrying heavy loads (n = 16, 8 women) or with minor or no such experience (n = 20, 9 women). The study was approved by the Regional Ethical Review Board in Stockholm.

Design and experimental protocol

The participants performed tests on five separate days with at least 1-day interval between test days. The tests included a reference test (see below), one unloaded and three loaded (20, 35 and 50 kg) walking tests at two speed (3 and 5 km h^{-1}). The order in which the different loads was carried was randomized. At the fifth occasion the strength tests were carried out approximately 30 minutes after the loaded walk. In addition, muscle tissue was obtained from biopsies, taken from the lateral part of the quadriceps muscle. The unloaded and loaded walk tests were carried out on carpets positioned in a rectangular shaped path (total length of 30 m per lap), consistent of 5 cm high massive soft material and included two equal blocks of 35 cm in height, 135 cm length and 50 cm width, mimicking outdoor walking in varying terrain.

Reference test

The aim of the reference test was to determine VO_2, pulmonary ventilation (VE), heart rate (HR) and blood lactate concentration (HLa) at standstill and at different submaximal work rates performed on a treadmill (Rodby, Södertälje, Sweden). Immediately after each submaximal exercise bout a fingertip blood sample for determination of blood lactate concentration (HLa) and rate of perceived exertion (RPE) for general, back, leg and breathing fatigue were obtained.[14] Finally, a conventional VO_2max test with stepwise increasing speed and inclination were carried out during which maximal values were obtained.

Walking tests

The participants walked for 5 min at the speeds 3 and 5 km h^{-1} with one minute of rest in between, carrying either 20, 35 or 50 kg or walking unloaded without backpack. During loaded walk the participant was strapped with a standard backpack filled with weights to according carry load. At the start of each test the participants stood still for two minutes and data collection at standstill was obtained. During the 5 min walks the participants completed nine laps when walking at 3 km h^{-1}, and 14 laps when walking at 5 km h^{-1}. The participants speed was paced via lights and signals using wireless lamps (Fitlight sports corporation, Aurora Ontario, Canada). The measurements of VO_2 and other parameters during carpet walking were the same as during the reference test. During all tests the participants carried three lightweight (27 g) electronic accelerometers, model GT3X+ (ActiGraph LCC, Pensacola, FL, USA), one on the hip, one on the chest and one on the dominant wrist capturing movements in all three planes (x, y and z).

Methods

VO_2 during the reference test was measured with a stationary system (Oxycon Pro) and during the carpet walking with a mobile online system (Oxycon mobile), both from Erich Jaeger GmbH, Hoechberg, Germany. These systems have been validated against the Douglas bag-method [15,16] and against each other without any notable differences.[17] The fingertip blood HLa was measured using a laboratory standard method (Biosen C-line, EKF Diagnostic, Barleben Germany). HR was continuously measured with a heart rate monitor (RS800, Polar Electro Oy, Finland).

Gross energy efficiency

The quotient between the VO_2 when walking with loaded weight in reference to VO_2 when walking unloaded was used as a proxy of carrying ability. It is an approach based on the equations of Taylor et al.[13] The equation was later expressed in a simpler form to produce an index (ELI, Extra load index) by Lloyd et al.[12] This index allows for comparison of relative gross energy efficiency during load carriage.

Strength tests

The participants started with a short warm-up session on a bicycle ergometer. Thereafter leg muscle strength was measured with loaded strength in a Smith-machine (Cybex International Medway, USA). Explosive squats with loads of 20, 35, 50 kg and a load equal to body mass were carried out. Before the test started the participants' shoulder width was measured and marked on the floor. The participant was instructed to stand with the insides of the feet just wider than these floor marks. The participant dropped 30 cm from an upright position and directly pushed upward. There were two separate tries on each weight with a few minutes of rest between. The highest result from each load was noted. All results were digitally recorded on a computer software (Muscle lab v.8.31, Ergotest Technology, Norway) and noted as power output in Watt.

Trunk muscle endurance was standardized according to Wyss et al. [18], which is a simplified method of Tschopp et al.[19] The participants were positioned horizontally on their elbows and front foot on the floor with 90º angle in shoulder and elbow joints with thumbs pointing up. The participants touched their lower back against a bar construction (see Supplemental Figure 1). In this position, participants were instructed to lift one alternating foot 5 cm above the floor every second. A metronome was used for 60 Hz tempo aid. When the participant no longer was able to hold the position with the lower back against the bar, the test was completed. Completed time to failure was registered as seconds.

Muscle biopsy

After a small incision through skin and fascia a Weil-Blakesley conchotome (Wisex, Mölndal, Sweden) was used to extract 75 – 100 mg of muscle tissue from vastus lateralis of the quadriceps muscle under local anesthesia with carbocain without epinephrine (AstraZeneca, Södertälje, Sweden) according to Ekblom[20]. The histochemical determination of muscle fiber type distribution was done with standardized laboratory methods.

Statistics

All statistical tests were performed in Statistica 12 (StatSoft Inc. Tulsa, OK, USA). All variables were normally distributed, except for trunk endurance and distribution of type IIx muscle fibers. Differences between sexes were performed using independent t-tests, Mann-Whitney U-test and chi-square, for normally, non-normally distributed and categorical variables, respectively.

Collinearity was assumed if Spearman correlations between variables exceeded rho = 0.7.

Most of the candidate factors were highly correlated. Hence no linear regression could be performed. We applied mediation analysis according to the model proposed by Preacher and Heyes [21] to investigate the possible mediators for sex difference and difference between participants with or without the long-term experience of load carrying. We tested candidates for mediation one by one, reporting bootstrapped paths coefficients and the corresponding bias adjusted 95 % CIs.

Results

Anthropometrics

In Table 1 anthropometric and physiological data are presented. There were differences between the sexes for most factors except for age, trunk muscle endurance, type I and IIa muscle fiber distribution.

Table 1 near here

VO_2 increased with both speed and load in both women and men (Table 2). For all loads, men have higher absolute VO_2 values but lower values in percent of VO_2max. Mean values for the 50 kg load at 5 km h^{-1} was 57 and 44 % of VO_2max in women and men, respectively. There was no difference between the sexes in ELI20, however in ELI35 and ELI50 women had significantly higher values.

Table 2 near here

HR was significantly lower on all loads and both speeds in men compared to women. Carrying 50 kg at 5 km h^{-1} the mean HR value for women was 149 ± 17 bpm and 120 ± 19 bpm for men.

HLa was low on all loads. The only sex difference was at 50 kg walking 5 km h^{-1}, where the mean HLa value was 2.00 ± 0.19 mM in women and 1.31 ± 0.57 mM in men ($p<0.05$).

RPE for general, back, leg and breathing fatigue was higher on all loads in women compared to men except for the lowest loads (20 kg, both speeds). RPE for the back was highest in both men and women. At the 50 kg load and the speed of 5 km h^{-1}, the RPE mean value for the back was 14.1 and 15.1 for men and women, respectively ($p<0.05$).

ELI analyzes

ELI20

For ELI20, significant correlations were found between body mass (rho = 0.40) and BMI (rho = -0.44), but not for any other of the investigated factors. No significant difference between sexes was found in ELI20, and hence no meaningful mediation analysis could be performed.

ELI35

A significant difference between sexes for ELI35 was found at both walking speeds (1.42 and 1.32 at 3km h^{-1} and 1.49 and 1.33 at 5 km h^{-1} for women and men respectively, $p<0.05$). For ELI35 significant correlations were found for height (rho = -0.50), VO_2max in l min^{-1} (rho = -0.37), leg strength (rho = -0.33) and for type IIa muscle fiber distribution (rho = 0.47). All candidates were tested for mediation, with a significant direct c-path between ELI35 and sex of -0.12 (p = 0.03). None of the candidates yielded an independent, significant mediation effect (all p>0.05) – see Table 3.

Table 3 near here

ELI50

ELI50 was found to be lower in men, compared to women (1.73 and 1.57 at 3km h^{-1} and 1.60 and 1.82 at 5 km $h^{-1}$for women and men respectively, $p<0.05$). Significant ($p<0.05$) bivariate correlations to ELI50 were found for height (rho= -0.63), body mass (rho= -0.77), BMI (rho= -0.58), absolute VO_2max in l min^{-1} (rho = -0.66) and leg muscle strength (rho = -0.67). No significant correlations were found for muscle fiber distribution, relative VO_2max (ml kg^{-1} min^{-1}) or trunk muscle endurance.

All candidates were tested for mediation between sex and ELI50 (Table 4). The direct effect of sex on ELI50 (c-path) was found to be 0.209 (p<0,05). Generally, body size, leg strength, and absolute aerobic capacity (VO_2max in l min^{-1}) all acted as mediators in uncontrolled analyses. Height, body mass and BMI all correlated strongly, and body mass provided the strongest mediation effect. When entering VO_2 (l min^{-1}), leg strength and body mass in a combined analysis (multimediator analysis), only body mass yielded a significant mediation effect (0.227, 95 % CI: 0.070 to 0.432) and a non-significant c´-path.

Table 4 near here

Experience of carrying loads

The ELI between the 16 experienced and the 20 inexperienced participants walking at 5 km h^{-1} were respectively: ELI20 1.08 ± 0.08 and 1.17 ± 0.09 ($p < 0.05$); ELI35 1.32 ± 0.12 and 1.43 ± 0.19 ($p = 0.058$); and ELI50 1.60 ± 0.16 and 1.79 ± 0.07 ($p < 0.05$).

Accelerometry

There was no relation between body length, body mass, carrying experience or sex and accelerometry counts, neither in the x-, y- and z- direction nor in total vector counts in any load or speed.

Discussion

The overall results of this study verify results for previous investigations.[1,2,6,22] Energy expenditure increases with both speed and load. Oxygen uptake on all loads are higher in men than women due to average heavier body mass in men. Energy expenditure in relation to body mass (relative VO_2) does not differ between the sexes on the different loads (data not shown). Åstrand[7] has suggested that the highest load for a healthy all-day physical work is about 40 % of VO_2max. In this study, this limit was almost reached by women for 50 kg load at 3 km h^{-1} (39%). At the higher speed of 5 km h^{-1}, this limit was passed by women carrying 35 (and 50) kg and by men when carrying 50 kg. It should be mentioned that when men carry 35 kg at 5 km h^{-1} the SD indicates that about half of them are stressed to 40 % of VO_2max or more. Data on RPE values support this. The data on energy expenditure during different walking speeds and loads are in essence similar to those earlier reported by Christie and Scott.[6] They used the same Åstrand health limit for prolonged work. Although the limit suggested by Åstrand deals mainly with all day manual industrial workload, physical workloads above 40 % may yield fatigue in shorter time than that. Roy et al. [23,24] have shown that load and not the carrying time is the most important factor for overuse injuries. It should be mentioned that the HLa values in this study were fairly low. This might partly be due to the short exercise time on each load, but other unknown factors cannot be excluded.

The ELI has been used as a proxy for load carrying capacity. For lighter loads (20 kg) there were no differences between the sexes, neither at 3 nor 5 km h^{-1} speed. Body mass and BMI were correlated to ELI20 at 5 km h^{-1} speed while there were no correlations to other factors studied. Therefore, a mediator analyzes could not be made. For the higher loads (35 and 50 kg) ELI was higher and differences between men and women were larger. Factors known to be positively related to load carrying capacity such as body mass, body height, and VO_2max was confirmed in this study. On the other hand, the non-related factors to load carrying capacity such as trunk muscle endurance and relative VO_2max are novel and previously not described. Regarding muscle fiber distribution, there is a mixed picture. At 35 kg and 5 km h^{-1} type IIa correlates to ELI but for ELI50 there seem to be no importance of muscle fiber distribution. Nor was muscle fiber composition a significant mediator for gender differences between sexes.

There were differences between the sexes in ELI values for both 35 and 50 kg loads but were these differences primarily due to the sex? Mediator analyses using ELI50 as an outcome and sex as the causal variable body size, leg strength and absolute aerobic capacity (VO_2max in l min^{-1}) all acted as mediators in uncontrolled analyses. Height, body mass and BMI all correlated strongly but body mass provided the strongest mediation effect. When entering VO_2max in l min^{-1}, leg strength and body mass in a combined analysis, only body mass yielded a significant mediation effect (0.227, 95 % CI: 0.070 to 0.432) resulting in a non-significant c´-path. Thus, ELI50 differed between sex and this difference is mediated via differences in body mass. Neither muscle fiber distribution, muscle strength, trunk endurance, height nor absolute and relative VO_2max were mediating the observed difference between sexes.

An interesting question is to what extent long term experience and, thus, load carrying training, is important for carrying ability in relation to other studied factors regarding the known extreme carrying performance among the Sherpas and Tibetan Highlanders. ELI values of 20 kg and 50 kg at 5 km h^{-1} were significantly lower in the group of men and women with prolonged experience in carrying heavy loads compared to those without such an experience (with a borderline difference for ELI35). None of the studied factors in this study could explain or mediated this difference. This result is supported by the finding in the study of Minetti et al.[11] The higher mechanical efficiency in Sherpas was also observed in the study by Bastien et al.[4] and was in part explained by a lesser trunk oscillation both during downhill and uphill walking. The improved carrying capacity in our participants could be due to the same mechanism, since no other factor explained the ELI differences between carrying experienced and control participants. On the other hand, the measurement of accelerometry counts did not show any relation to any of the studied factors in this study. This might indicate that the extreme carrying capacity in Sherpas is, at least to some extent, due to an extreme long-time training experience, perhaps even from a young age, which far exceeds the carrying training experience in our group of carrying-trained participants.

Strength and limitation

Participants in the present study were both trained and relatively untrained in carrying heavy loads, which limits the risk of positive selection. A strength is that several important factors were studied. All physiological data were collected with validated methods in a controlled environment. Walking on a soft carpet with some elevations mimicking track walking is as far as we know uniquely done in this study. Mediation analyses is also a strength in this study.

36 participants is generally considered as a good sample in these type of studies, however, 19 men and 17 women is still a relatively small statistical sample and the results should be interpreted with that in mind. Another limitation could be the method used for trunk endurance, but we have no indication that another method for evaluation of trunk endurance would correlate better with carrying ability.

Statistical consideration

Using bootstrapped mediation allows control for the independent parameters and provide point estimates to assess the significance or non-significance of mediation effects. Although it could be considered a somewhat exploratory approach, bootstrapped mediation provides a stability to the results that other analyses lack. An alternative statistical approach to evaluate and analyze the carrying capacity between the sexes could have been to perform a backward exclusion linear regression including sex, using VO_2max (l min^{-1}), leg strength and body mass as independent variables and ELI50 as dependent. Relative VO_2max was not included, since body mass is already taken into consideration in the analyses. We performed such analysis. The result showed that body mass was the only variable left in the final model (data not shown). This indicates that the results are not dependent on the statistical model used.

Conclusions

This study contains novel findings on how parameters important for load carrying relates to load carriage as extra load index (ELI) in both men and women, with minor- or long term experience of load carriage. The study showed that body mass, without sex differences, and experience of carrying heavy loads are the dominant factors for the ability to carry heavy loads. Even though the effect of experience alludes to the need for extensive carrying training, no causality can be proven. Load carry training intervention studies is therefore suggested for future investigations.

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Supplemental Figure 1.

Trunk muscle endurance test being performed with the lower back pressed against the bar while lifting alternating foot until exhaustion.

Table 1. Anthropometric and physiological data for the participants, women and men (mean ± SD, min-max, and statistical difference between the sexes).

Anthropometrics	Women (n=17)		Men (n=19)		Differences
Age (years)	28.8 ± 5.6	21-41	29.8 ± 5.7	20-41	0.636
Body mass (kg)	66.1 ± 8.9	52-88	82.5 ± 7.0	72-102	0.000*
Height (m)	1.68 ± 0.07	1.54-1.80	1.81 ± 0.05	1.73-1.92	0.000*
BMI ($kg \cdot m^{-2}$)	23.3 ± 2.5	19.4-29.5	25.1 ± 1.6	21.3-29.6	0.011*
Shoulder width (cm)	42.3 ± 2.0	38.0-46.0	47.6 ± 2.8	45.0-55.0	0.000*
VO_2max ($l \cdot min^{-1}$)	3.24 ± 0.35	2.55-3.94	4.59 ± 0.56	3.53-5.45	0.000*
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	49.5 ± 4.3	42.3-56.0	55.8 ± 4.8	49.0-63.8	0.000*
Trunk endurance (s)	120 ± 60	64 - 324	114 ± 43	61-228	0.740
Leg strength (watt)	807 ± 158	587-1140	1288 ± 174	995-1620	0.000*
Muscle fiber distribution in *Vastus Lateralis* of the *Quadriceps muscle*					
Type 1 (%)	50.6 ± 12.1	30.2-62.5	46.5 ± 11.2	24.0-62.9	0.322
Type IIa (%)	35.8 ± 13.3	15.4-64.0	29.2 ± 10.7	11.6-46.0	0.118
Type IIx (%)	8.9 ± 4.3	5.4-20.8	16.0 ± 9.5	5.4-43.5	0.009*

** denotes $p<0.05$ difference between women and men. BMI = Body Mass Index, VO_2max = Maximal Oxygen uptake*

Table 2. Oxygen uptake (VO_2) in $l \cdot min^{-1}$ (mean ± SD) and in percent of VO_2max (mean ± SD) and ELI at walking speed 3 and 5 $km \cdot h^{-1}$ carrying 20, 35 and 50 kg in women and men, respectively

	Women			Men			
Speed/load	$l \cdot min^{-1}$	% VO_2max	ELI	$l \cdot min^{-1}$	% VO_2max	ELI	*p* =
3 km · h⁻¹							
20 kg	0.80 ± 0.08	23 ± 2	1.14 ± 0.11	1.02 ± 0.15	22 ± 3	1.13 ± 0.13	0.68
35 kg	1.05 ± 0.08	26 ± 3	1.42 ± 0.17	1.19 ± 0.12	26 ± 3	1.32 ± 0.14	0.05*
50 kg	1.28 ± 0.07	39 ± 4	1.73 ± 0.17	1.42 ± 0.16	31 ± 5	1.57 ± 0.21	0.02*
5 km · h⁻¹							
20 kg	1.17 ± 0.11	32 ± 3	1.11 ± 0.94	1.37 ± 0.18	30 ± 4	1.15 ± 0.97	0.19
35 kg	1.48 ± 0.14	45 ± 4	1.49 ± 0.19	1.63 ± 0.18	36 ± 4	1.33 ± 0.14	0.04*
50 kg	1.86 ± 0.11	57 ± 5	1.82 ± 0.18	1.97 ± 0.16	44 ± 6	1.60 ± 0.16	0.00*

** denotes significant ($p<0.05$) ELI difference between women and men. ELI = Extra Load Index, VO_2 = Oxygen uptake*

Table 3. Bootstrapped mediation (ab-) paths coefficients (95 % CI) for proposed mediators between sex and ELI35. Relation between sex and ELI35 after mediation is expressed as c´-path and corresponding p-value.

	ab-coefficients	**95 % CI**	**c´-path**
Height (cm)	-0.124	-0.27 to -0.02	0.00 (ns)
Body mass (kg)	-0.073	-0.210 to 0.049	-0.049 (ns)
BMI (kg/m^2)	0.002	-0.065 to 0.072	0.119 (ns)
VO_2 ($l \cdot min^{-1}$)	-0.064	-0.244 to 0.076	-0.058 (ns)
VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	0.022	-0.054 to 0.103	-0.144 ($p < 0.01$)
Leg strength (watt)	-0.053	-0.200 to 0.057	-0.068 (ns)
Trunk endurance (s)	0.002	-0.013 to 0.031	-0.124 ($p < 0.03$)
Type I (%)	0.014	-0.007 to 0.082	-0.140 ($p < 0.02$)
Type IIa (%)	-0.029	-0.089 to 0.001	-0.097 (ns)
Type IIx (%)	-0.014	-0.073 to 0.042	-0.111 (ns)

Table 4. Bootstrapped mediation (ab-) paths coefficients (95 % CI) for proposed mediators between sex and ELI50. Relation between sex and ELI50 after mediation is expressed as c´-path and corresponding p-value.

	ab-coefficients	**95 % CI**	**c´-path**
Height (cm)	0.154	0.023 to 0.320	0.063 (ns)
Body mass (kg)	0.225	0.126 to 0.369	-0.016 (ns)
BMI ($kg \cdot m^{-2}$)	0.071	0.015 to 0.118	0.140 ($p < 0.05$)
VO_2 ($l \cdot min^{-1}$)	0.224	0.093 to 0.392	-0.009 (ns)
VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	- 0.042	-0.154 to 0.404	0.252 ($p < 0.01$)
Leg strength (watt)	0.228	0.092 to 0.396	-0.020 (ns)
Trunk endurance (s)	0.002	-0.035 to 0.011	0.209 ($p < 0.01$)
Type I (%)	-0.023	-0.095 to 0.009	0.224 ($p < 0.01$)
Type IIa (%)	0.009	-0.011 to 0.082	0.195 ($p < 0.01$)
Type IIx (%)	-0.028	-0.101 to 0.009	0.230 ($p < 0.01$)