Original Article

Strength training in seniors: The knowledge of positive aspects of eccentric training in elderly is sparse

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ABSTRACT

Eccentric (lengthening) resistance training respectively muscle work requires a lower share of cardiac activity in comparison to concentric (shortening) muscle work. Especially in seniors suffering from cardiovascular diseases (still the most common cause of death in industrialized countries) this kind of activity is predisposed due to its possibility of high stimulation of musculoskeletal system only partly (20-25%) stimulating cardiovascular system. Comprehension of positive aspects was addressed for a sample of people doing regular work out while having access to concentric and eccentric training stations. 38 females (57 ± 15.7 years / 163.3 ± 19.4 cm / 63.6 ± 10.4 kg) and 36 males (57.6 ± 16.9 years / 177.4 ± 6.9 cm / 80.6 ± 8.7 kg) visiting at least once a week a fitness mall with access to eccentric and concentric training stations were asked concerning cardiovascular diseases, their corresponding risk factors and their own experience with eccentric muscle training. Differences in the perception of eccentric muscle training compared to concentric training were reported by 18 women and 24 men, however reported Rates of perceived Exertion measured by BORG-Scale (6-20) did not significantly differ. A positive Bias that especially persons with cardiovascular illnesses respectively risk factors preferred this kind of activity was not detectable and knowledge of positive aspects of eccentric training was sparse. General practitioners are encouraged to inform patients of the existence of positive aspects of eccentric muscle training and to motivate patients to absolve their training respectively. **Key words:** STRENGTH TRAINING, ECCENTRIC EXERCISES, SENIORS, CARDIAC REHABILITATION.

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INTRODUCTION

With increasing age, physiological and psychological performance capacity decreases (Hoppeler et al. 2009). Beside the decrease in endurance capacity e. g. a reduction of maximum oxygen uptake (VO_2max) a decrease in strength results, which is mainly for older people a problem due to loss of independence leading to the necessity of e.g. a constant accommodation in rest homes (Doherty 2003; Zintl & Eisenhut 2009). To improve life conditions in advanced age, seniors should constantly train their muscle strength (Hoppeler et al. 2009). Some hints exist, that senior training once a week is not enough but healthy person in the middle of the life span or later should at least be active for 30 minutes several times a week, optimal daily (Hoppeler et al. 2009; Pate, Pratt, Blair, Haskell, Macera, Bouchard, Buchner, Ettinger, Heath & King 1995). However, that a high share of elderly people suffer from a lack of physical activity is generally known (Stuck, Elkuch, Dapp, Anders, Iliffe & Swift, 2002). Furthermore, most activity programs for activating seniors aiming to improve endurance capacity with a strong focus on cardio-vascular system (Hoppeler et al. 2009; Lippuner, von Overbeck, Perrelet, Bosshard, Jaeger 1997; Neuhauser, Thamm & Ellert 2013; Shepard & Balady 1999). In principle, this is not negative due to well proven positive effects of aerobe training on cardiovascular risk, blood pressure and metabolic syndrome respectively diabetes (Hoppeler et al. 2009; Zintl & Eisenhut 2009). However, with increasing age not only endurance capacity decreases but also muscle strength and coordination skills decrease making it hard to fulfill daily challenges in higher ages (Hoppeler et al. 2009). In the group of over 80-year old seniors e.g. falls are in central Europe the most important reason for a visit in a hospital having often negative consequences such as long hospital visits with even more disgusting and long-lasting recovery times often resulting in the inability keeping the household on its own (Hoppeler et al. 2009; Lippuner, von Overbeck, Perrelet, Bosshard, Jaeger, 1997; Stuck et al. 2002). Given these facts, specific programs which improve power, flexibility and coordination are therefore for seniors highly recommended. The fact that active humans even in higher ages react well on physical activity is generally accepted (Hoppeler et al. 2009). The conventional concentric strength training is executed by many older people, but especially experience with eccentric training and especially the knowledge of this kind of training possibility seems to be smaller. This might be a consequence of the fact, that only few training facilities offer eccentric work-out stations. In principle, since the investigations in the 1950`s of Abbott, Bigland & Ritchie, describing effects of eccentric muscle activity and its positive effects (Fig. 1) (Abbott, Bigland & Ritchie 1952) the knowledge and understanding of the underlying mechanism improved constantly (Abbott, Bigland & Ritchie 1952; Gearhart, Goss, Lagally, Jakicic, Gallagher, Gallagher & Robertson 2002). Later it was shown that eccentric muscle activity does not follow the classic contraction pattern of ATP driven mechanism with Aktin-Myosin and Ca_2^+ Influx but a more likely understanding of winding filament Hypothesis seems to be a valid way in order to develop an understanding of the underlying mechanism (Nishikawa 2016). The winding filament hypothesis states plausible molecular mechanisms for effects of both Ca_2^+ influx and cross bridge cycling on titin in active muscle (Nishikawa 2016). This hypothesis proposes that the N2A region of titin binds to actin upon Ca_2^+ influx and that the PEVK region of titin winds on the thin filaments during force development because the cross-bridges not only translate but also rotate the thin filaments (Nishikawa 2016). Simulations demonstrate that a muscle model based on the winding filament hypothesis can predict residual force enhancement on the descending limb of the length–tension curve in muscles during eccentric contraction (Nishikawa 2016). From a more practical point of view eccentric muscle activity plays not only a role in many different movement patterns of daily life such as going downstairs with the need of negative work against gravity forces or in different sports such as skiing making it necessary to absorb shear forces by femoral muscles (Vogt, Däpp, Blatter, Weisskopf, Suter, Hoppeler 2003).

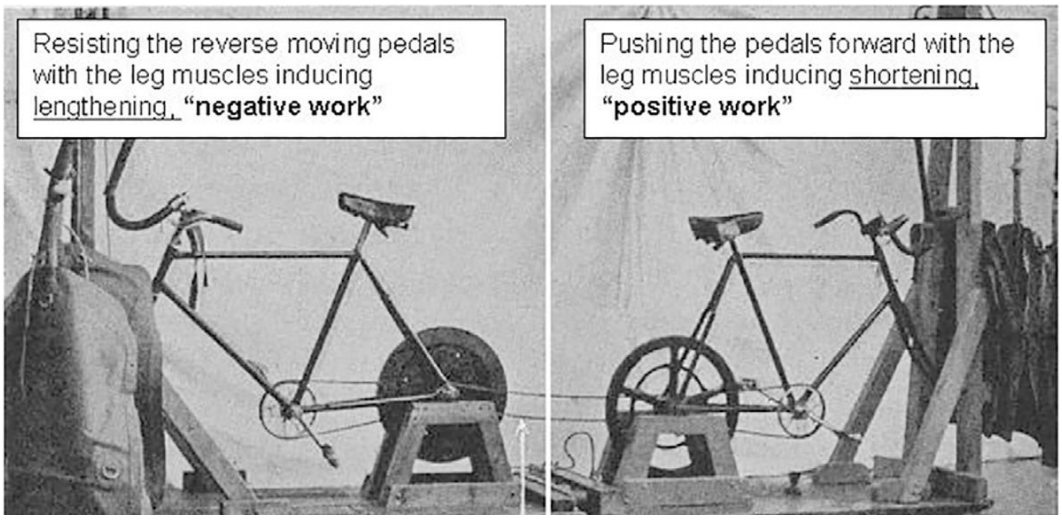

Figure 1a. Two bikes and one chain – the experimental ergometer consisting of two bicycles positioned back to back and coupled with a single chain. During the forward pedaling condition (right), the participant's leg muscles (e.g. quadriceps) produced force while shortening ('positive work'), whereas resisting the pedal action (left), the muscles generated force while lengthening ('negative work').

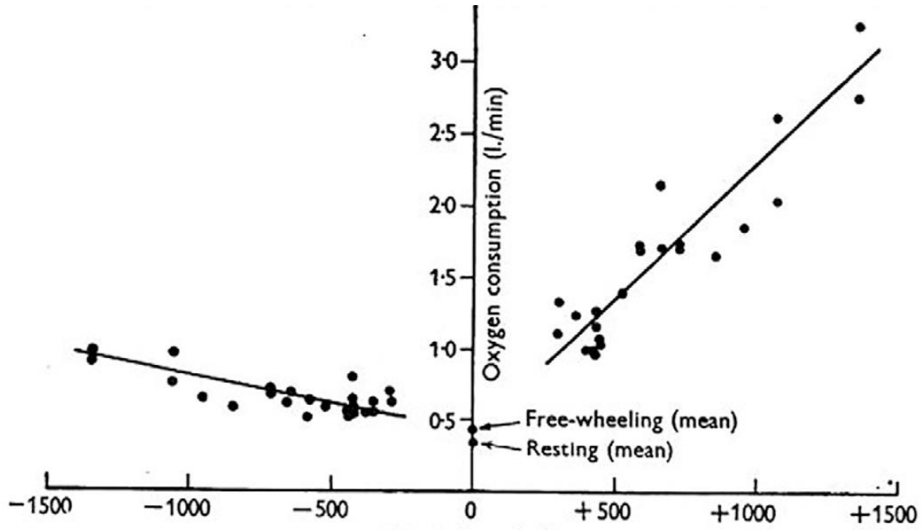

Figure 1b. The original figure illustrating variations in oxygen consumption measured during positive and negative work. Note that absolute work rates were similar between the positive and negative conditions. Figure 1a and 1b are from the original paper (Abbott, Bigland & Ritchie 1952 cited from Gearhart et al. 2002; Elmer & LaStayo 2014).

Keeping Fig. 1.b in mind it becomes evident that due to a lower oxygen consumption a smaller stress on cardiovascular system results due to a potential lower VO_2 flow (Laroche, Joussain, Espagnac, Morisset, Tordi, Gremeaux, Casillas 2013). Especially in older persons with cardiovascular affections this training method might be especially well suited due to the fact of stimulating musculoskeletal system with a high extent while only using cardiac system with a share (one quarter to one-fifth) in comparison to concentric muscle activity (Gearhart et al. 2002, Isner-Horobeti, Dufour, Vautravers, Geny, Coudeyre, & Richard 2013). Steiner, Meyer, Lippuner, Schmid, Saner & Hoppeler 2004). Concerning its application and the rate of perceived exertion it's to mention that some hints exist, that eccentric training is less demanding than concentric training: e.g., in a study of training with older people executed by LaStayo, Ewy, Pierotti, Johns &

Lindstedt (2003a) only a minimum and short increase of muscle soreness was found in participants of an eccentric training. Furthermore, only the eccentric group showed a significant increase of force (60%), balance (7%) and especially the ability of going down the stairs (21%) after training sessions. Furthermore, in the get-up and go Test only the eccentric training group showed an improvement of fall risk (LaStayo, Ewy, Pierotti, Johns & Lindstedt 2003a). Furthermore, eccentric training in comparison to concentric training leaded to a higher distance in a 6-minute walking test probably due to a better postural stability (Besson, Joussain, Gremeaux, Morisset, Laurent, Casillas, Laroche 2013). Despite these potential positive aspects, the knowledge of positive effects of this kind of training seems to be sparse. In fact, it really seems that this kind of training is not very well known and a consciousness of positive aspects of eccentric training especially in persons with cardiac affections is not very common. This fact leads to the aim of this study to investigate the current situation in eccentric training such as the perception while training, the existence of a preference for such training, the potential existence of a knowledge or even a higher share of persons executing eccentric training when affected by cardio-vascular diseases.

MATERIAL AND METHODS

Participants

38 female (57 ± 15.7 years / 163.3 ± 19.4 cm / 63.6 ± 10.4 kg) and 36 male (57.6 ± 16.9 years / 177.4 ± 6.9 cm / 80.6 ± 8.7 kg) seniors with regular (more than once a week) strength training activity in a gymnastic hall in Switzerland with the possibility of eccentric training.

Measures

After questioning the first points BORG-Scale (6-20) was administered for the questions concerning the perception of muscle work (Fig. 2). BORG-Scale (6-20) is nowadays a very common and valid instrument for quantifying rate of perceived exertion mainly in endurance sport for which it was originally developed (Borg, 1962; Borg, 1970; Borg, 1998; Borg, 2004; Chen, Fan, Moe 2002; Chung, Zhao, Liu, & Quach 2015; Gearhart et al. 2002, Löllgen, 2004; Scherr, Wolfarth, Christle, Pressler, Wagenpfeil & Halle 2013). However, despite the fact that this scale is often used in strength training, BORG-Scale (6-20) was not developed for this kind of activity (Gearhart et al. 2002). To mention, the number of repetitions might interact with rated values of perceived exertion e.g. a few repetitions with high weight seem to be harder than many repetitions with little weight, making it hard to generally use this scale for such activities (Gearhart et al. 2002).

Procedures

The shown questionnaire (Fig. 3) was applied personally by an interviewer with expert knowledge about the positive aspects of eccentric training. The study was conducted in accordance with the Declaration of Helsinki.

Analysis

Mean and Standard Deviation for the number of trainings per week, time since starting professional strength training, the average time of a work-out, the number of concentric and eccentric exercises, the average time for an exercise as well as the perceived exertion for concentric and eccentric exercises. For analyzing differences between reported BORG-values in women versus men pairwise, two-sided t-Tests were conducted (Stier 1998; Bortz 2005). Furthermore, parameters of cardiovascular situations were questioned calculating mean and standard deviation for a myocardial infarct, increased blood pressure, arrhythmia and valvular heart disease. For analyzing data Microsoft excel and SPSS 22 were used.

Eccentric training in the elderly

Please fill out _____ respectively mark with a cross □
Age (years): _____
Sex: □ male □ female
size in cm: _____
weight in kg: _____
How many times a week (average) do you work out (only strength training)? _____
Since when do you work out? (Years respectively months) _____
What is the average time of a work out (minutes)? _____
How many exercises do you make with concentric muscle activity? _____
How many exercises do you make with eccentric muscle activity? _____
How much time do you need per exercise (concentric/eccentric)? _____
How many repetitions do you make while concentric exercises? _____
How many repetition do you make while eccentric exercises? _____
Do you feel any difference between concentric and eccentric exercises? □ yes □ no
Which intensity (BORG-Scale 6-20) do you perceive (average) while concentric exercises? _____
Which intensity (BORG-Scale 6-20) do you perceive while eccentric exercises? _____
Do you suffer from a coronary heart disease: □ yes □ no?
When yes: myocardial infarct □ yes □ no
How many myocardial infarct _____
Coronary heart disease without myocardial infarct: □ yes □ no
Blood pressure (higher 140/90 mmHg): □ yes □ no
Arrhythmia: □ yes □ no
Valvular heart disease: □ yes □ no
Was the eccentric training specially recommended by a medical person? □ yes □ no
Do you know from positive effects of eccentric muscle activity especially when affected by heart diseases?
□ yes □ no

Thank you for your participation!

Figure 2. The questionnaire

Rate of Perceived Exertion
BORG-Scale (6-20)

6 No exertion
7 Extremly light
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard
16
17 Very hard
18
19 Extremly hard
20 Maximal Exertion

Figure 3. BORG-Scale (6-20)

RESULTS

In the sample of women 2.5 ± 3.1 trainings per week were absolved. The average time since exercising was about 7.5 year (89.0 ± 59.8 months), the average time of a work-out session was 45 ± 17.3 minutes. In average, 9 ± 3.1 concentric training stations and 2.1 ± 1.5 eccentric training stations were absolved. The average time for a station was 2 min 16 ± 1 min 12 sec.

Concerning differences in rate of perceived exertion while concentric versus eccentric exercises 18 women reported a difference while exercising concentric versus eccentric. 20 women reported no difference. Reported intensity by the 18 women in concentric exercises was 12.6 ± 1.1 (BORG-Scale, 6-20) and in eccentric exercises 12.9 ± 1.6 (BORG-Scale, 6-20) although not significant ($p = 0.35$). In the sample of the 36 men questioned 2.8 ± 1.8 trainings per Week were absolved. The average time since exercising was about 5 years (66.3 ± 58.1 months), the average time of a work-out was 41 ± 16.1 minutes. In average, 9.7 ± 2.8 concentric training stations and 3 ± 1.2 eccentric training stations were absolved. The average time was 1 min 58 ± 44.2 sec. Concerning differences in rate of perceived exertion in concentric versus eccentric exercise 24 men reported a difference while exercising concentric versus eccentric. 12 men reported no difference. Reported intensity in concentric exercises was 14.6 ± 4 (BORG-Scale, 6-20) and in eccentric exercises was 14.4 ± 4.2 (BORG-Scale, 6-20) although not significant. ($p = 0.72$ / $n = 21$).

In women, no myocardial infarct could be detected. Blood pressure was increased in 3 and an Arrhythmia was four times reported. A valvular heart disease could be detected in three persons. Concerning the positive effects of eccentric muscle activity only four women reported having knowledge concerning positive aspects and were encouraged by medical persons to train accordingly, but only one of them was suffering from a cardiovascular disease.

In men, out of the sample of 36 only 2 men reported a prior myocardial infarct, one men reported a diagnosed coronary heart disease without myocardial infarct. Four men reported increased blood pressure, one men arrhythmia and one men a valvular heart disease. Only five men reported to have knowledge on positive aspects of eccentric training and an encouragement by medical personal to absolve eccentric training was given. Only one of them was suffering from increased blood pressure.

Interestingly, men compared to women reported significantly higher BORG-values while concentric ($p = 0.006$) as well as eccentric ($p = 0.048$) exercises.

DISCUSSION AND CONCLUSIONS

The aim of this study was to elucidate personal experience with eccentric strength training in a sample of seniors regularly visiting a gymnastic hall. Therefore, a sample of 38 women and 36 men were questioned concerning their experience with this kind of training activity. It was detectable, that in this selective sample of visitors of a gymnastic hall offering concentric as well as eccentric training stations only a small group was aware of the positive aspects of eccentric training. Furthermore, an awareness of positive aspects of this kind of muscle activity in cardiac patients was in the majority missing. The analyzed, selective sample of gymnastic hall visitors absolved an average of 2.5 ± 3.1 trainings (women) and 2.8 ± 1.8 trainings (men) per week enduring around 45 minutes. Despite of a selection bias of physical active seniors, the total amount of time spent physically active has to be taxed in the lower range of recommendations (Hoppeler et al. 2009). The recommendations indicate for an adult at least being active for 30 Minutes or more most of the day's best daily (Pate, Pratt Blair, Haskell, Macera, Bouchard, Buchner, Ettinger, Heath, King 1995). In a previous study

with seniors it was shown that neither eccentric nor concentric training twice a week was enough (Hoppeler et al. 2009). Furthermore, very often in senior weight load recommended for good reasons of security – primum non nocere – is not sufficient (Hoppeler et al. 2009). This points out, that the majority of questioned which are undoubtful a selective sample of gym hall visitors, does not show sufficient physical activity. To go back to the initial question of knowledge and awareness of special benefits of eccentric training this knowledge was in the vast majority missing. Furthermore, no tendency was detectable that mainly persons with cardiac affections prefere this kind of training. Neither the advantages of protection of cardiovascular system parallelly using musculoskeletal system nor a tendency, that concerned persons with cardiac illnesses prefer this kind of activity could be detected. Focusing back on the aspect of the study of reported BORG-values in concentric and eccentric exercise results are not straight forward e.g. other studies revealed, that despite increasing work over time (12 weeks of training program) Borg-values remained in a stable area and did not parallelly increase with increasing workload (Elmer, Marshall, McGinnis, Van Haitsma & LaStayo 2013; Elmer, Danvind & Holmberg 2013, LaStayo, Marcus, Dibble, Frajacomo, Lindstedt 2014; Löllgen 2004; Laroche, Joussain, Espagnac, Morisset, Tordi, Gremeaux &Casillas 2013). Further studies analyzing exertion in upper body e.g. with arm ergometer, the same performance leaded to lower BORG-values in eccentric versus concentric muscle activity when holding work load constant (Elmer, Marshall, McGinnis, Van Haitsma & LaStayo, 2013; Elmer, Danvind & Holmberg 2013). For three constant levels it was shown, that oxygen consumption, cardiac output, heart rate and ventilation was 25-50 % lower when eccentric versus concentric muscle work was done and arm specific Borg values (6-20) were lower in eccentric work with 8-12 versus 9-16 with concentric work in a comparable range of the reported values in our study (Elmer, Marshall, McGinnis, Van Haitsma & LaStayo 2013; Elmer, Danvind & Holmberg 2013). For clarification, further studies are necessary for judging validity of BORG-Scale (6-20) in eccentric training. To sum up, general knowledge of eccentric training was very sparse in the analyzed sample and a consciousness for the sinful mechanism of eccentric training e.g. for fall prophylaxis was in the vast majority missing. (LaStayo et al. 2003b). It is recommended that medical persons inform and encourage seniors to constantly work out and also absolve eccentric training.

PRACTICAL APPLICATIONS

Despite of a selective sample of physical active seniors, the total amount of time spent physically active has to be taxed in the lower range of general recommendations for seniors. The recommendations indicate for an adult at least being active for 30 Minutes or more most of the day's best daily.

As proven from theoretical and practical aspect especially in seniors with cardiovascular diseases e.g. status after myocardial infarct eccentric training seems to be a good way to stimulate musculoskeletal system preserving cardiovascular system. However, the knowledge of these positive aspect in seniors is sparse. General practitioners are therefore encouraged to inform their patients especially with cardiovascular diseases concerning the positive aspects of eccentric muscle training

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