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Effects of isokinetic and isotonic training programmes on heart rate and blood pressure in high school students

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Summary

Study aim: To compare the effects of 6-week isokinetic and isotonic training programmes on heart rate and blood pressure in high school students.
Material and methods: Twenty-nine healthy, untrained male student subjects aged 15 – 18 years participated in the study. They were assigned into 3 groups: control (C; n = 11), and subjected to isokinetic (IK; n = 8) or isotonic (IT; n = 10) training lasting 6 weeks, 3 days a week. Isokinetic exercises consisted of 3 sets of 20-s extensions/flexions (both knees) at 180º/s, spaced by 30-s intermissions, the isotonic ones - of 4 sets of extensions (both knees) at 50% of the predetermined one repetition maximum, spaced by 30-s intermissions. Heart rates (HR) and blood pressure were determined before and after the training period, both pre- and post-exercise.
Results: Mean resting HR and exercise-induced HR-increase significantly decreased post-training in IT group (by 19 and 24%, respectively; $p<0.001$). The exercise-induced HR-increase significantly increased post-training in IK group (by 17%; $p<0.001$). Significant ($p<0.01$) training-induced decreases in the systolic pressure (SBP) were found in both training groups (IT and IK, by 7 and 6%, respectively).
Conclusions: The results may be of practical importance for athletes and health professionals who administer open-chain resistance exercises.

Key words: Isokinetic exercise – Isotonic exercise – Heart rate – Blood pressure – Knee joint

Introduction

Isotonic and isokinetic exercises are two modes of resistance training that can be used to improve muscle strength and performance. Isotonic exercise training is characterised by variable joint speed against a constant resistance. The amount of force generated also varies depending on the position of limb and its range of motion. Isotonic exercises are cost-effective and relatively simple to execute and have been used for many years to increase muscle strength in rehabilitation [7]. However, concentric isotonic exercises can only provide loads that can be overcome by weakest point in the range of motion and an accurate control of movement velocity can be difficult. In contrast, isokinetic exercise provides an accommodating resistance at constant velocity which, theoretically, allows for maximal force production at all points throughout the active range of motion and provides an angle-torque curve for each separate muscle action [2]. Isokinetic resistance training has also been used for strength testing and training in clinical settings [19]. Positive effects of weight training on changes in body composition, strength and power are known to occur [8,12]. However, traditional non-circuit weight training has not generally been regarded as important in producing increases in cardiovascular fitness. Most studies investigating cardiovascular fitness focused on aerobic power [8], few studies being devoted to the effects of non-circuit weight training on the heart rate [14]. Resting and recovery heart rates are elements of cardiovascular fitness and therefore will reflect positive changes in cardiovascular fitness as a result of training [20].

The heart rates at rest, exercise and recovery together with blood pressure are very important parameters in all types of sports activities and although more oxygen is consumed by large muscle groups, the rate response is essentially the same for e.g. knee or arm extensions [11]. Studies on the effects of resistance training on circulation

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parameters are, however, not numerous and this prompted us to undertake this study, aimed at demonstrating which training programme would be more effective in improving resting, exercise and recovery heart rates and blood pressure, as such information would be useful for specific patient populations and for athletes.

Material and Methods

Subjects: Twenty-nine healthy, untrained male student subjects aged 15 – 18 years volunteered to participate in the study. All subjects were non-smokers, used no drugs affecting the cardiovascular system and had no contraindications to exercise. All of them submitted their written consents to participate after having been informed about the study protocol and possible risks involved. The study was approved by the local committee of ethics.

Methodology: The subjects were randomly assigned into 3 groups. One of them served as a passive control (C; n = 11), the other ones were subjected to training – isokinetic (IK; n = 8) or isotonic (IT; n = 10). The trainings lasted 6 weeks, 3 sessions a week, lasting 15 min each and consisted of exercising knee flexors and extensors (IK group) or extensors only (IT group). One repetition of both kinds of exercises was applied at maximum resistance (1RM); isokinetic exercises consisted of 3 sets of 20-s extensions/flexions (both knees) at 180º/s, spaced by 30-s intermissions, using Cybex II dynamometer (Lumex Inc.USA). Isotonic exercises consisted of 4 sets of extensions (both knees) at 50% of 1RM, spaced by 30-s intermissions. No exercise was applied to the control group.

Before and after training period, heart rates were measured pre- and post-exercise, as well as 15, 30, 45 and 60 s post-exercise using a polar hearth rate monitor (Polar RS100, Finland). Blood pressure were recorded in sitting position pre-exercise when the right leg exercised using a sphygmomanometer and stethoscope.

Data analysis: One-way ANOVA was applied with the Duncan's multiple range post-hoc test in case of significant interaction. Student's *t*-test for paired data was applied to individual differences. The SPSS 15.0 software was used, the level of $p \leq 0.05$ being considered significant.

Results

The results are presented in Tables 1 – 3 and in Fig. 1. No significant between-group differences in physical characteristics were found except BMI (Table 1).

Table 1. Mean values (±SD) of age and basic somatic variables of young male subjects

Group / Variable	Isotonic n = 10	Isokinetic n = 8	Control n = 11
Age (years)	17.0 ± 0.9	17.7 ± 1.0	16.6 ± 0.7
Body height (cm)	172.2 ± 6.7	169.6 ± 7.5	173.2 ± 6.2
Body mass (kg)	59.7 ± 5.4	62.2 ± 12.0	60.3 ± 4.1
BMI	20.2 ± 2.0	22.6 ± 2.7*	20.1 ± 1.7

* Significantly ($p<0.05$) different from other groups

Mean pre-exercise heart rate was significantly lower post-training compared with the pre-training state in the IT group (by 19%; $p<0.001$) and the exercise-induced increase was in that group also significantly lower post-training (by 24%; $p<0.001$). In contrast, in the IK group no significant change in the pre-exercise HR was noted and the exercise-induced increase was in that group significantly higher post-training (by 17%; $p<0.001$) compared with the pre-training state (Table 2).

The post-exercise changes in the heart rate are presented in Fig. 1. All changes exhibit parallel courses, the between-group and training-induced changes corresponding to those presented in Table 2.

Table 2. Mean values (±SD) of heart rates (HR) and of individual, exercise-induced changes (Δ)

Variable	Group	Isotonic (IT) n = 10	Isokinetic (IK) n = 8	Control n = 11
Pre–training	Pre-exercise	90.6 ± 6.6	83.3 ± 17.1	84.0 ± 9.7
	Δ	31.8 ± 8.0*	24.0 ± 6.4*	28.4 ± 7.1*
Post–training	Pre-exercise	73.2 ± 6.8 º	78.0 ± 12.0	83.4 ± 7.8
	Δ	20.4 ± 8.6*	47.3 ± 15.5*^	28.0 ± 5.7*
Post-pre training	Pre-exercise	-17.4 ± 6.6*^	-5.3 ± 18.0	-0.5 ± 3.2
	Post-exercise	-28.8 ± 12.9*^	18.0 ± 8.5*^	-0.9 ± 4.9^

* Significant ($p<0.001$) exercise- or training-induced change; Significantly ($p<0.01$) different from: º Control group; ^ Other groups

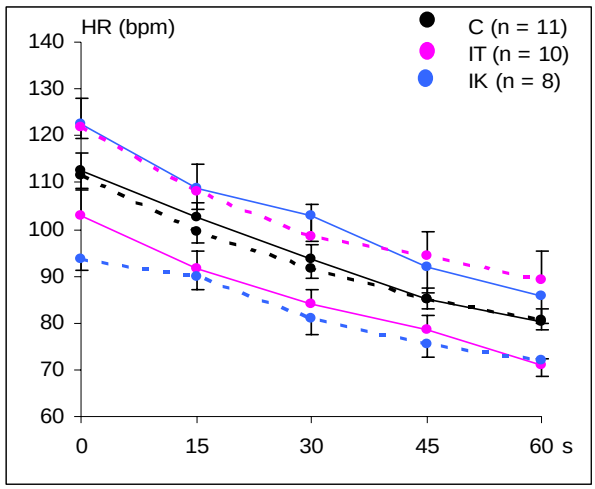


Fig. 1. Mean values (±SE) of post-exercise changes in heart rate (HR) pre-training (solid lines) and post-training (dotted lines)

Legend: C – Control group; IT – Isotonic training group; IK – Isokinetic training group

No significant between-group differences in blood pressure were noted pre-training. Significant ($p<0.01$) training-induced decreases in the systolic pressure (SBP) were found in both training groups (IT and IK, by 7 and 6%, respectively). No significant change was noted in the control group. Further, no significant training-induced changes were noted in the systolic-diastolic differences in either group (Table 3).

Table 3. Mean values (±SD) of systolic (SBP) blood pressure and of systolic/diastolic differences (SBP - DBP)

Variable	Group	Isotonic (IT) n = 10	Isokinetic (IK) n = 8	Control n = 11
Pre–training	SBP	118.6 ± 10.7	121.8 ± 5.8	115.8 ± 4.3
	SBP - DBP	44.6 ± 9.8	48.0 ± 7.7	45.6 ± 5.6
Post–training	SBP	110.4 ± 8.6	114.8 ± 8.1	116.0 ± 4.4
	SBP - DBP	42.4 ± 11.8	51.3 ± 11.7	44.7 ± 5.7
Post-pre difference	SBP	-8.2 ± 7.0*	-7.0 ± 4.9*	0.2 ± 2.4 ^
	SBP - DBP	-2.2 ± 10.8	3.3 ± 9.4	-0.9 ± 3.0

* Significant ($p<0.01$) training-induced change; ^ Significantly ($p<0.01$) different from other groups

Discussion

Heart rate increases in the IK-group may have resulted from the muscle contraction velocity affecting the cardio-respiratory responses during repetitive isokinetic exercises [10,13] since isokinetic concentric contractions elicit greater HR changes than isokinetic eccentric contractions in knee extension exercises [22]. However, Okamoto *et al*. [21] reported lower heart rates for isokinetic training than in this study and suggested that high-intensity eccentric contractions exert only a small stress to the cardiovascular system, thus being applicable to resistance training.

Reductions in the resting heart rate in the IT-group may be the result of an increase in the parasympathetic /diminished sympathetic input ratio [1]; this is likely accompanied by an increased stroke volume [14]. However, other authors [3,4,9,13,17,24] reported significant increases or no changes in HR and blood pressure in subjects practicing free weight, universal gym, nautilus training or conventional resistance training. Furthermore, some researchers [5,6,16,23] found significant decreases in resting HR in subjects practicing weight lifting, circuit weight training or nautilus training.

Isokinetic training induced a decrease in the resting blood pressure but had no significant effect on resting HR while isotonic training affected the resting heart rate. However, other authors [6,15,18,22] found significant increases in HR and blood pressure in subjects exercising on isokinetic ergometers (Cybex II, Kinetic Communicator Model 500-H, Cybex 6000 or Cybex Norm). No comparable data, however, were found in the available literature to evaluate the observed effects on resting HR.

The presented results may be of practical importance for athletes and health professionals who administer open-chain resistance training exercises, as well as to researchers who use isotonic and/or isokinetic training modes of resistance exercise to examine muscle functions. In addition, future studies should examine different types of resistance speed and of exercises to compare with IK training and IT training muscle action.

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