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The Effects of Different Exercise Programs on Knee Muscle Strength and H:Q Ratios of Sedentary Males and Females

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Abstract

Objectives: Knee muscle strength is highly important for both sedentary and athletic people. For the reasons of both rehabilitation of injuries and performance development, strength is regarded as one of the most important elements of sports. The present study aims to determine the effect of different exercise protocols on knee muscle strength and H:Q ratios of young sedentary males and females.

Methods: A total of 115 healthy and sedentary people 62 males (23.10±4.50 years, 71.90±8.90 kg and 177.80±10.30 cm) and 53 females (22.10±5.30 years, 54.40±6.90 kg and 166.60±6.00 cm) voluntarily consented to take part in the study. Participants were divided into randomly four separate groups according to exercise types and exercises applied during 12 weeks (control, pilates, cardio, resistance exercises groups). Resistance exercise movements were made within 60% of 1-RM for each participant over 3 days during a week with 3 sets of 10-12 repetitions. CEG exercises were performed on a treadmill for 45 minutes over 3 days in a week with a 60% overloading rate. Pilates exercises were performed for 45 minutes over 3 days during a week under the supervision of a coach. Pilates exercises were divided into three different parts: (1) mat exercises (4 weeks), (2) Thera-band plastic resistance exercises (4 weeks) and, finally, pilates ball exercises at a beginner level (4 weeks).

Results: There were significant differences between the pre- and post-exercises of knee muscle strength for REG, CEG and PEG after 12 weeks both gender and legs ($p<0.05$). Measures of muscle strength in both leg elicited substantial side differences in both flexor and extensor muscle strength. On average the female participants showed a 12.1% weaker flexor muscle strength (52.1±12.7 vs. 45.3±11.9 Nm, $p<0.05$) and a 6.7% stronger extensor muscle strength in the dominant leg (120.3±24.7 vs. 112.2±25.8 Nm, $p=0.036$). These data converted into H:Q ratios indicates that the knee H:Q ratio of dominant leg was 41.3±6.5% as compared with 38.6±6.9% ($p>0.05$) in the non-dominant leg.

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Conclusion: In conclusion, regular resistance, cardio and pilates exercises caused a significant increase in flexors and extensors muscle strength and H:Q ratios of males and females.

Keywords: Exercise, Hamstring, Pilates, Strength

Introduction

Muscle strength is highly important for both sedentary and athletes. For the reasons of both rehabilitation of injuries and performance development, strength is regarded as one of the most important elements of sports (Magalhaes et al.. 2004). When measuring muscle strength, it is especially important to ascertain muscle balance and to compare relative strengths of dominant & non-dominant and agonistic & antagonistic muscle groups (Derviseviç and Hadziç, 2012). In these measurements, isokinetic dynamometers are commonly used (Kong and Burns, 2010). In this context, the peak torque ratio of hamstrings to quadriceps (H:Q) of athletic people is regarded as an important parameter to detect the amount of muscle balance (Almosnino et al., 2012; Andrade Mdos et al., 2012; Lund et al., 2005; Karinkanta et al., 2005; Stel et al., 2004). H:Q ratio is emphasized to be an indicator of lower-extremity injuries, as well (Devan et al., 2004; Costa et al., 2009; Aagaard et al., 1998; Hewett et al, 2008). H:Q ratio should be between 0.50 and 0.80, depending on varying knee-angles and angular velocities (Calmens et al., 1997; Rosene et al., 2001; Orchard et al., 1997). Muscular strength obtains from resistance exercise programs are account for developing velocity and movement coordination as well as to promoting balance and functionality (Delecluse et al., 1995; Bottaro et al., 2007). These findings highlight the significance of practising resistance exercise in the context of human health, and it is actually preached as part of physical activity programs for young, adults and seniors people (ACSM, 2009). Conventionally, an eight-week program is essential to accomplish substantial and apparent improvements in strength and muscular performance, although gains may be monitored prior to this period (Landin and Nelson, 2007). Several studies have focused on the strength obtains from short duration resistance exercise sessions, which differ from two to three sessions per week for up to two weeks (Prevost et al., 1999; Brown and Whitehurst, 2003). Prevost et al. (1999) found an improvement in knee muscle peak torque following short-term training that was parallel to the gains improved later 6 to 10 weeks of training. In the constant exertion to progress the efficiency of training routines, new methods are continuously implemented at all levels of strength and conditioning. Mutual application and anecdotal back up controlled liable research has been showed resistance exercise is an efficient training technique for

improving muscular strength and explosive power (McCurdy et al., 2009; Shoepe et al., 2011; Rhea et al., 2009). Conversely the strength training, an ordinary endurance training program progress aerobic capacity and has various beneficial influences (Cornelissen et al., 2009). Due to the physiological influential of endurance training on skeletal muscle have thus been suggested to be antagonistic to increases in strength and muscle. There is evidence that aerobic exercise may development muscle function (Verney et al., 2006; Ferrara et al., 2006), although many research have reported that aerobic training does not modify whole muscle size (Jubrias et al., 2001; Short et al., 2004; Weiss et al., 2007). To date, studies have been examined to effects of resistance exercise programs or aerobic exercises on knee muscle strength. Also, no study has examined to effects of pilates exercise on knee muscle strength. Moreover, the effects of different exercise types on muscle strength, and the comparison of these exercises with regard to gender is an issue with limited consideration in existing literature. For that reason, the present study aims to determine the effect of different exercise protocols on knee muscle strength and H:Q ratios of young sedentary males and females.

Methods

Participants

The study was a randomized controlled trial. In order to discourse the main hypothesis represented herein, we separated healthy female and male with no experience in any form of structured resistance training. Afterwards, whole participants randomly separated into four groups. To compare the effect of different exercise protocols on knee muscle strength and H:Q ratios, 3 experimental groups and 1 control observation group. Previous to and during their participation in the research, participants carried on their normal nutritional and lifestyle routine, but warded off any involvement in strenuous exercise activities. Potential participants of the study were selected from the Inonu University students. A randomized controlled study was conducted on 115 healthy and sedentary people. Sixty-two males (23.10±4.50 years, 71.90±8.90 kg and 177.80±10.30 cm) and fifty-three females (22.10±5.30 years, 54.40±6.90 kg and 166.60±6.00 cm) voluntarily consented to take part in the study. In order to be included in the study, participants had to meet the following criteria: (a) being physically healthy (we looked whether any disorder in appearance), (b) not having been included in any exercise program for at least 6 months before the study, (c) not using any supplemental food to increase performance, (d) not having any medical disability which would affect the study (this question asked all participants), (e) not having any drug addiction. All participants have been sufficiently informed about the importance of the study and of the risks involved. They

have read and signed consent forms. All procedures implemented in the study comply with the Helsinki declaration and have been approved by the Malatya Ethical Committee. A total of 160 participants randomly were assessed for eligibility. Seventeen participants were ineligible, as they were physically active (for, they said that regular exercise have made). 143 participants were placed as in the three exercise groups (n=35) and one in the control group (n=38). Before pre-testing session 15 participant withdrew in the study. After pre-test, thirteen participants was excluded for both test scores incorrect and exercise irregularity. Finally, the study was completed 115 participants after exercise session and post-test.

Exercise Procedures

Resistance exercise group (REG, M=15, F=11): 1 week before beginning to administer a 1 repetition maximum (1-RM) strength test on participants, 1-RM weights for resistance exercises were administered separately on 2 different days at the same hour of the day and for 6 exercises Barbell bench press (BBP), Machine long pull (MLP), Dumbbell shoulder press (DSP), Standing barbell curl (SBC), Machine leg extension (MLE), Machine abdominal curl (MAC) included in the protocol. While determining 1-RM weight, the following procedure was undertaken: a) all participants were made to warm up before starting the test (riding a bike for 10 minutes, slight stretching exercises for 5 minutes and resistance exercises for upper and lower extremities in 2-3 sets of 8-20 repetitions with a light weight), b) the test was started with lifting light weights, c) weights were increased gradually, d) when participants stated that they could not lift the weights, the test was stopped, e) participants were allowed to try 3 or 4 times during the test, e) the maximum weight that participants could lift on the first attempt within full movement range was recorded as 1-RM. Resistance exercise movements were made within 60% of 1-RM for each participant over 3 days during a week (Monday, Wednesday and Friday) with 3 sets of 10-12 repetitions during 12-week period. Participants were allowed 1 minute of rest between sets and 2 minutes between movements. All resistance movements were made by 4 coaches and all participants were motivated verbally during the study.

Cardio exercises group (CEG, M=16, F=13): Target pulse rates of participants were calculated using the Karvonen method: Target Heart Rate (THR) = Maximum Heart Rate (MHR) – Resting Heart Rate (RHR) x Overloading Density +RHR (Karvonen et al., 1957). CEG exercises were performed on a treadmill for 45 minutes over 3 days in a week (Monday, Wednesday and Friday) with a 60% overloading rate during 12-week period. During all

cardio exercises, participants were monitored and motivated by 4 coaches for the efficiency of the study.

Pilates exercises group (PEG, M=14, F=13): Pilates exercises were performed for 45 minutes over 3 days during a week (Monday, Wednesday, and Friday) under the supervision of a coach during 12-week period. Pilates exercises were divided into three different parts: (1) mat exercises (4 weeks), (2) Thera-band plastic resistance exercises (4 weeks) and, finally, pilates ball exercises at a beginner level (4 weeks, Pilates, 2001).

Control group (CG, M=17, F=16): CG participants were asked not to perform any kind of exercise or activity that could affect their muscle strength for 3 months.

All participants were made to perform warm up exercise or 20% of activity periods before starting exercises and for 10% of their exercise period at the end of working out. Isokinetic muscle strength and H:Q ratios of each group is calculated before each exercise and again after 3 months. Exercise procedures were shown in table 1.

Table 1: Content of exercise protocols

Groups (n=82)	Exercise	Set x repetition	1-RM%
REG (n=26)	Barbell bench press Machine long pull Dumbbell shoulder press Standing barbell curl Machine leg extension Machine abdominal curl	3x 10-12	60
	Exercise	**Set x repetition**	**Duration**
PEG (n=27)	**Mat exercises** (Neutral spine, Head nod, Arms over, Angel arms, Pelvic clock, Knee folds)	2 x 4-6	45
	Thera-Band Exercises (T push up with Thera-band, Strength Leg Lowering, Hip abduction, Biceps Curls, Arm raise with thera-band, Anti-rotation press)	2 x 8-10	
	Plates Ball exercises (Ball push up, Ball scapular protraction, Ball squat on wall, Ball Biceps curl, Ball crunch, Ball hyper-extension)	2 x 10-12	
CEG (n=29)	Exercise	Density	Duration
	Treadmill	60%	45

(Abbreviations: REG: Resistance exercise group, CEG: Cardio exercise group, PEG: Pilates exercise group, CG: Control group, RM: Repetition Maximum)

Isokinetic Test

Isokinetic peak torque of the dominant and non-dominant leg was measured with Biodex system 3 isokinetic dynamometers (Biodex Medical Systems, Inc., Shirley, NY, USA 2000). Calibration adjustments of dynamometers were approved regularly in line with the recommendations of the manufacturing company during the data collection period. Participants were placed safely in a chair at a sitting position for the test. In order to immobilize upper body movements for the participant, he or she was restrained with both a cross-wise pectoral girdle and lap belt. Participants were asked whether or not they were comfortable. 90° anatomic position of the knee was observed with a ganiometer and a joint range of movement (ROM) was 70° [from 90° to 20° knee Xexion (0° = full extension)]. Participants started the test with a warning beep from the dynamometer and ended the test with the same noise. The measurement of peak isokinetic concentric knee extension and knee flexion torque in both legs were taken at 60°/s. Participants were given five times to warm up at submaximal concentric contractions for both leg and then performed the maximal concentric contractions eight times. During all isokinetic tests, participants were allowed to rest for 3 minutes between sets and 15 seconds between serials. The resting interval and the number of sets were selected as accordance with the ACSM recommendations.

Statistical Analysis

Statistical analysis procedures started with *"Skewness and Kurtosis"* scores, visual explanations of histogram plots and *"Kolmogorow Smirnov"* tests within normality analysis in order to test whether data were homogenous. As variances show a normal distribution, "Paired Samples T" Test was conducted to test the significance between test scores of groups. All statistical analyses were calculated with SPSS 17.0 software program and the significance level is recognized as $p<0.05$. The reliability of each isokinetic test was assessed by intra-class correlation coefficient (ICC) as suggested by Weir, 2005. The results indicated that these tests were highly repeatable: ICC of extensor peak torque dominant was 60°/sn (ICC=0.96), 180°/sn (ICC=0.95), 300°/sn (ICC=0.96), non-dominant 60°/sn (ICC=0.95), 180°/sn (ICC=0.94), 300°/sn (ICC=0.94), flexor peak torque dominant 60°/sn (ICC=0.96), 180°/sn (ICC=0.95), 300°/sn (ICC=0.97), non-dominant 60°/sn (ICC=0.96), 180°/sn (ICC=0.96), 300°/sn (ICC=0.96), and H:Q ratios dominant 60°/sn (ICC=0.96), 180°/sn (ICC=0.95), 300°/sn (ICC=0.96), non-dominant 60°/sn (ICC=0.95), 180°/sn (ICC=0.96), 300°/sn (ICC=0.96).

Results

Female participants of whose dominant and non-dominant legs generated both lower knee flexor-extensor muscle strength and H:Q peak torque ratios at 60°/s than male participants all of groups. The measurements of muscle strength elicited important differences in both flexor and extensor muscle strength.

Table 2: Flexion-extension peak torque and H:Q ratios of groups.

Parameters	Sex		Groups							
			REG		CEG		PEG		CG	
60°/**s**			Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant	Dominant	Non-dominant
Peak torque (Flexion, Nm)	F	Pre-	54.2±13.6	49.6±12.7	53.0±7.90	47.3±10.1	50.38±10.0	47.6±11.2	51.1±9.19	48.6±10.0
		Post-	66.1±12.4	61.9±13.0	63.3±7.84	57.3±12.4	63.19±10.9	59.2±11.9	48.6±7.34	50.1±11.3
		p	0.002*	0.006*	0.010*	0.021*	0.001*	0.043*	0.747	0.866
	M	Pre-	92.9±25.1	83.8±24.5	91.1±23.7	81.2±23.9	99.4±21.4	84.1±24.8	96.1±17.6	86.5±24.9
		Post-	119.7±28.6	108.6±24.7	109.7±27.1	99.0±21.8	118.8±20.7	104.1±24.0	89.9±22.8	86.6±24.7
		p	0.001*†	0.011*†	0.023*†	0.031*†	0.001*†	0.002*†	0.692	0.976
Peak torque (Extension, Nm)	F	Pre-	121.1±23.8	115.4±26.5	119.0±20.1	112.8±23.8	123.9±19.3	114.5±25.0	117.5±19.9	105.9±23.7
		Post-	151.4±25.6	143.8±25.3	138.5±11.7	135.5±24.1	140.3±18.5	133.8±25.9	120.3±18.4	110.4±24.8
		p	0.017*	0.021*	0.047*	0.025*	0.038*	0.021*	0.842	0.899
	M	Pre-	179.40±24.8	165.2±27.8	201.8±40.1	163.1±26.1	183.5±36.4	164.2±23.2	196.9±28.7	178.8±28.8
		Post-	238.80±32.4	210.5±26.9	234.3±30.8	196.9±27.5	227.6±29.4	199.5±24.7	185.8±29.7	179.2±26.1
		p	0.001*†	0.001*†	0.031*†	0.001*†	0.012*†	0.001*†	0.164	0.872
H:Q (%)	F	Pre-	42.3±5.30	38.1±6.2	39.5±5.16	38.6±6.0	41.7±5.75	38.3±5.2	41.9±10.8	39.4±5.9
		Post-	54.5±7.28	48.7±5.8	49.1±7.38	47.3±5.9	50.2±7.45	46.9±5.1	39.8±9.19	40.2±5.8
		p	0.001*	0.002*	0.001*	0.011*	0.001*	0.012*	0.894	0.966
	M	Pre-	43.7±9.24	41.5±7.9	45.6±8.79	40.2±6.4	49.8±9.65	39.9±6.4	49.1±7.77	48.5±6.4
		Post-	54.4±9.84	51.6±8.8	53.6±10.3	49.3±7.9	59.4±9.81	48.8±7.5	48.4±8.86	48.9±7.1
		p	0.001*	0.010*	0.012*	0.017*	0.026*	0.011*	0.842	0.899

(Abbreviations: REG: Resistance exercise group, CEG: Cardio exercise group, PEG: Pilates exercise group, CG: Control group, H:Q: Hamstring/Quadriceps ratio,: significance differences between pre- and post-test, †: significance differences between female and male, $p<0.05$)*

On average the female participants showed a 12.1% weaker flexor muscle strength (52.1±12.7 vs. 45.3±11.9 Nm, $p<0.05$) and a 6.7% stronger extensor muscle strength in the dominant leg (120.3±24.7 vs. 112.2±25.8 Nm, $p=0.036$). These data converted into H:Q ratios indicates that the knee H:Q ratio of dominant leg was 41.3±6.5% as compared with 38.6±6.9% ($p>0.05$) in the non-dominant leg.Also, the male participants scores displayed a 13.2% stronger flexor muscle strength (94.8±25.2 vs. 83.9±27.1 Nm, $p=0.016$) and a 13.5% weaker extensor muscle strength in the non-dominant leg (190.4±27.4 vs. 167.9±25.7 Nm, $p=0.001$). H:Q ratios shows that the knee H:Q ratio of dominant leg was 53.9±8.8% as compared with 49.6±7.5% ($p>0.05$) in the non-dominant leg (table 2). Baseline and 12 week knee flexor, extensor muscle strength and H:Q ratios data was indicated in table 2. There were significant differences between the pre- and post-exercises of knee muscle strength for REG, CEG and PEG after 12 weeks both gender and legs ($p<0.05$).

Discussion

The current study mainly was investigated on determine the effect of different exercise interventions on gender, and dominant, non-dominant flexor, extensor muscle peak torque and H:Q ratios. Therefore, the study revealed that knee flexor, extensor muscle peak torque and H:Q ratios of all groups (except CG), in terms of gender and both leg higher after 12 week exercise programs. The findings of the present study partly support the suggested hypothesis, as the male's knee muscle strength flexor and extensor ratios higher than females. But, the other hypothesis not verified about a variety exercise.

These study results backed up prior findings in suitable literature (Anderson et al., 2008; Irez et al., 2011; Moughan et al., 2012). Anderson et al., (2008) conducted a study to determine the effect of combining elastic and free weight resistance on the effect of muscle strength. They found that that peak strength increased to 4,5% after 7 weeks. Rhea et al. (2009) found that the increase is 18% after resistance exercise 12 weeks (24). In that study, it is found that there is an approximately 20% improvement on flexion and extension peak torque and H:Q ratios of males and females after 12 weeks. Previous researches were indicated that regular attendance in physical activity has a favorable effect on knee muscle strength (Irez et al., 2011; Moughan et al., 2012). Some studies conducted on the effect of pilates exercises on strength development stated that pilates exercises have a positive effect on strength (Irez et al., 2011; Petrofsky et al., 2005). In the present study, it is found that pilates exercises performed for 12 weeks have a positive effect on flexion and extension peak torque and H:Q ratios for both males and females. The results of the study were parallel with

examples from literature. Therefore, it may be stated that regular pilates exercises may support improvement knee flexor, extensor and H:Q ratios both gender and leg.

Hooten et al. (2012) found that resistance and cardio exercises, when performed for 3 weeks, have a positive effect on flexion and extension peak torques. It is stated that flexion and extension peak torque ratios improved among elder people who performed walking exercises. In the study, there is a statistically significant increase in flexion and extension peak torque and H:Q ratios among males and females who regularly performed cardio exercise for 12 weeks. The findings of the present study are similar to the above examples. Regular cardio exercises can positively affect flexion and extension and H:Q ratios of males and females. According to the results of the study, regular varied exercise significantly improves both flexion and extension peak torques of females. However this improvement is significantly lower than the change in flexion and extension peak torques of males. Both males and females have different results after different exercises for H:Q ratios. In other words, flexion and extension peak torques of males are significantly more improved than females in different exercises. However, improvement in H:Q ratios of both males and females is similar. In literature, it is stated that the fact that muscle strength development of females is different, especially during adolescence, refers to the fact that hamstring muscle groups of males develop more than females during adolescence (Hewett et al., 2008). This difference, emerging during adolescence, between sexes can cause weakness in hamstring and quadriceps muscle strength (Andrade Mdos et al., 2012).

Study Limitations

The findings of the present study should be interpreted in the context of its limitations. The first limitation we identified was that we did not measure knee muscle strength different velocities and therefore unable to compare the different angular velocities. Secondly, we conducted knee muscle strength only concentric contractions. But, if we compared to with eccentric contraction both leg and gender, it could be beneficial for the literature. In addition to, if the research were intervened longer time (24 weeks), it might be more profit to participants.

Conclusion

In conclusion, regular resistance, cardio and pilates exercises caused a significant increase in knee muscle flexor, extensor peak torque and H:Q ratios both leg and gender. Our results recommend that regular resistance, cardio and pilates exercises may be useful tool for people who are endeavor to develop of their muscle strength. Moreover, conducting these

three types of exercises regularly may contributed the development of hamstring and quadriceps muscle strength both leg and gender. From these findings, we estimate that by intervening resistance, cardio and pilates exercises may ameliorate their physical abilities.

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