The Relationship between Musculoskeletal Strength, Physiological Characteristics and Knee Kinesthesia following Fatiguing Exercise

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INTRODUCTION

- Fatigue has been identified as a risk factor for injury in athletes and trained individuals
  - Injuries occur early/late in season
    - Fatigue due to poor pre-season conditioning
    - Fatigue due to cumulative effects of training late in season
- Athletes likely experience a combination of peripheral and central fatigue during practice/games
  - Peripheral fatigue – changes inside muscle fiber
  - Central fatigue – failure to maintain required or expected force due to CNS alterations
- Fatiguing exercise may negatively impact neuromuscular control and proprioception, resulting in:
  - Altered muscle activation patterns and lower extremity mechanics
  - Deficits in joint position sense and threshold to detect passive motion
- Several musculoskeletal and physiological mechanisms may contribute to fatigue onset
  - Individuals with higher levels of strength and fitness may be better able to offset fatigue

STUDY PURPOSE AND SPECIFIC AIMS

- The objective of this study was to establish the relationship between musculoskeletal and physiological characteristics and changes in knee proprioception following fatiguing exercise
- Specific aims of study were to establish the relationship between:
  - Isokinetic strength of the quadriceps and hamstrings
  - Isokinetic knee flexion/extension ratio
  - Peak oxygen uptake (VO_2Peak)
  - Lactate threshold (LT)

  And changes in knee threshold to detect passive motion (TTDPM) in flexion and extension following fatiguing exercise

EXPERIMENTAL DESIGN AND METHODS

STUDY DESIGN

- Cross-sectional, correlational research design

SUBJECTS

- 20 healthy, physically active females (28.7±5.6 years, 165.6±4.3 cm, 61.8±8.0 kg, BF: 23.3±5.4%)

EXPERIMENTAL DESIGN AND METHODS, CONT'D

PRODECURES

- Visit 1
  - Familiarization session for TTDPM in extension and flexion of the dominant knee (Biodex Multi-Joint System 3 Pro Dynamometer, Shirley, NY) (Figure 1)
    - 20° knee flexion start position, arm speed 0.25°/sec
  - Isokinetic strength of quadriceps and hamstrings (Biodex Multi-Joint System 3 Pro Dynamometer, Shirley, NY)
  - VO_2Peak and LT
    - Graded treadmill exercise test
      - Inspired/expired gases collected with TrueOne2400 (ParvoMedics, Sandy, UT)
      - Constant speed, incline increased by 2% every 3-minutes until volitional fatigue
      - Blood lactate collected during final 30s of each stage (LacatePro, Arkray Inc, Japan)

Figure 1. TTDPM Set-up

- Visit 2
  - Pre- and post-fatigue testing
    - TTDPM
    - Isometric knee strength (Biodex)
  - 7-Station Fatigue Protocol (Figure 2)
    - Station 1: 5-min run at 95% VO2 pace
    - Station 2: 3-min run at 110% VO2 pace
    - Station 3: 2-min of push-ups (modified)
    - Station 4: 2-min of sit-ups (YMCA partial curl-up)
    - Station 5: 3-min of 12-in step-ups
    - Station 6: 3-min run at 110% VO2 pace
    - Station 7: 2-min run at 115% VO2 pace
  - If a subject was not volitionally fatigued at the end of station 7, the station continued, and with each additional minute, the incline of the treadmill was increased by 1%

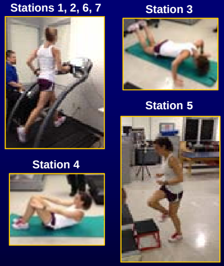

Figure 2. Fatigue Protocol

STATISTICAL ANALYSIS

- Shapiro-Wilk tests and normality plots assessed normality of each variable
- Wilcoxon signed rank tests determined TTDPM and strength differences from pre- to post-fatigue
- Spearman's Rho correlation coefficients determined relationships between variables of interest

RESULTS

- Significant decreases in isometric hamstring strength and flexion/extension ratio were revealed following fatigue (Table 1)

Table 1. Pre- and Post-Fatigue TTDPM and Isometric Strength Changes

	Pre-Fatigue						Post-Fatigue						Pre-Post
	Mean		SD	Median	LQ	UQ	Mean		SD	Median	LQ	UQ	p-value
TTDPM Ext (°)	1.54	±	0.96	1.33	0.76	2.02	1.54	±	0.77	1.53	0.90	1.90	0.65
TTDPM Flex (°)	-1.52	±	1.09	-1.05	-1.82	-0.94	-1.51	±	1.51	-2.27	-2.02	-0.83	0.48
Quad Strength (%BW)	217.3	±	47.7	213.5	178.4	249.6	214.1	±	42.4	200.3	180.3	256.1	0.681
Ham Strength (%BW)	116.9	±	25.3	115.2	106.2	128.0	105.5	±	24.4	109.2	88.4	128.5	0.004**
Flex/Ext Ratio	0.55	±	0.11	0.54	0.49	0.60	0.50	±	0.10	0.50	0.41	0.58	0.012*

Wilcoxon Signed Rank Test utilized to determine significant differences from pre- to post-fatigue
**Significantly different at the P<0.01 level *Significantly different at the P<0.05 level

- No significant correlations were revealed between isokinetic knee strength, flexion/extension strength ratio, VO_2peak or LT and changes in TTDPM in flexion or extension (Table 2)

Table 2. Pre- to Post-Fatigue ΔTTDPM Correlation Coefficients

	Pre- to Post- Fatigue TTDPM			
	Extension		Flexion	
	r	p-value	r	p-value
Quad Strength (%BW)	0.019	0.937	-0.162	0.496
Ham Strength (%BW)	0.065	0.784	-0.005	0.982
Flex/Ext Ratio	0.236	0.316	0.202	0.394
VO2 Peak (ml/kg/min)	0.281	0.230	0.256	0.276
LT (%VO2peak)	0.344	0.137	-0.357	0.123

Spearman's Rho Correlation Coefficients utilized

Table 3. Pre-Fatigue TTDPM Correlation Coefficients

	Pre-Fatigue TTDPM			
	Extension		Flexion	
	r	p-value	r	p-value
Quad Strength (%BW)	-0.194	0.412	0.069	0.774
Ham Strength (%BW)	-0.199	0.401	0.017	0.942
Flex/Ext Ratio	-0.231	0.024*	0.024	0.920
VO2 Peak (ml/kg/min)	-0.500	0.005**	0.172	0.467
LT (%VO2peak)	-0.087	0.717	0.077	0.748

Spearman's Rho Correlation Coefficients utilized
*Significant at the p<0.05 level, **Significant at the p<0.01 level

- A significant, low correlation was revealed between flexion/extension strength ratio and pre-fatigue TTDPM in extension (Table 3)
- Significant, moderate correlations were revealed between VO_2peak and both pre-fatigue and post-fatigue TTDPM in extension (Tables 3-4)

Table 4. Post-Fatigue TTDPM Correlation Coefficients

	Post-Fatigue TTDPM			
	Extension		Flexion	
	r	p-value	r	p-value
Quad Strength (%BW)	-0.138	0.561	-0.003	0.990
Ham Strength (%BW)	-0.138	0.561	-0.082	0.731
Flex/Ext Ratio	-0.152	0.523	0.016	0.947
VO2 Peak (ml/kg/min)	-0.520	0.019*	0.279	0.233
LT (%VO2peak)	0.118	0.620	-0.205	0.385

Spearman's Rho Correlation Coefficients utilized
*Significant at the p<0.05 level

SUMMARY AND CONCLUSIONS

- Results did not demonstrate a significant relationship between the chosen modifiable musculoskeletal and physiological characteristics and changes in proprioception following fatigue, and this may be due to the overall high fitness level of the subjects
- The significant correlation between VO_2Peak and TTDPM in extension suggests a linear relationship between individuals with higher aerobic capacity and better proprioception
- Future studies should consider different subject populations, other musculoskeletal strength characteristics, and various modalities of proprioception to determine the most important contributions to proprioceptive changes following fatigue

NMRL Website Poster

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