EFFECT OF A MULTI-SEGMENTAL ROTARY EXERCISE PROGRAM ON HIP EXTERNAL ROTATOR AND ANKLE INVERTOR STRENGTH

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BACKGROUND AND PURPOSE

- Lower extremity (LE) sprains / strains account for 36% of all injuries treated in emergency rooms[1]
- Many intrinsic and extrinsic risk factors have been associated with LE injury[2]
- Neuromuscular performance capabilities influence an individual's response to external loads and forces[3]
- Both dynamic control of foot pronation and core stability appear to be important contributors to force dissipation[4]
- Integrated LE function can be enhanced through improvement of neuromuscular activation and coordination[5-7]
- The closed-kinetic chain core-LE linkage within the transverse plane has not been thoroughly investigated
- The purpose of this study was to quantify the effectiveness of a rotary closed-chain LE strengthening program for improvement of isometric force output of the hip external rotators and ankle invertors

SUBJECTS AND PROCEDURES

- Participants were 19 college students (21.9 5.7 years of age)
  - 4 males: 177.8 6.9 cm; 90.5 10.7 kg; 15 females: 168.7 5.5 cm; 70.3 12.1 kg
- Exclusion Criteria:
  - Participation in an intercollegiate sport within previous year; LE injury sustained within the 3 weeks of testing
  - Joint-specific surveys administered to quantify functional status prior to initiation of strengthening program
    - Oswestry Disability Index (ODI)
    - International Knee Documentation Committee knee survey (IKDC)
    - Foot and Ankle Ability Measure - Sport Subscale (FAAM)
  - Hip external rotation (HER) and ankle inversion (INV) force output measured by hand-held dynamometer (R & L)
    - Resistive force standardized through use of stabilization belt (Figures 1 & 2)
  - Wall sit hold (WSH) muscle endurance test administered to both right (R) and left (L) extremities (Figure 3)
  - Exercise program initiated within 72 hours of pretesting – participants met 3 times per week for 3 weeks
    - 2 HER/INV exercises (Figures 4 & 5) performed for each extremity on Standing Firm System® (New Castle, PA)
  - Measurements repeated after 3-week program; 15-level (-7, 0, +7) Global Rating of Change (GRC) administered
    - Intraclass correlation coefficient (ICC) calculated to assess measurement precision
    - Dependent t-tests (α=.05) and 90% minimum detectable change (MDC_{90}) used to assess improvement
    - Receiver operating characteristic (ROC) analysis used to assess association between strength gain and status

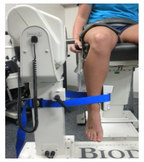


Figure 1


Figure 2


Figure 3

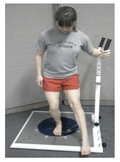


Figure 4

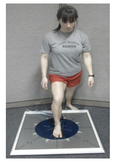


Figure 5

RESULTS

- ICC (2,K) for comparison of R and L pre-test average of 3 values: HER =.882; INV=.914
  - MDC_{90} for assessment of strength gain: HER =0.95 kg (2.09 lbs); INV=1.59 kg (3.50 lbs)
- Statistically significant pre-test to post-test change observed for INV (R & L), HER (R), WSH (R & L), and ODI
- ROC analysis demonstrated an association between WSH improvement and HER strength gain (Figure 6, Table 2)
  - 80% of cases with HER increase (R & L Avg) ≥ 0.56 kg (1.23 lbs) had ≥ 8 sec improvement in WSH (R & L Avg)
    - 78% of cases with < 0.56 kg (1.23 lbs) HER increase had < 8 sec WSH improvement
- ROC analysis demonstrated an association between lack of survey score increase and lack of strength gain
  - 85% of cases without any improvement in IKDC had < 3.44 kg (7.57 lbs) INV-L increase (Figure 7)
  - 80% of cases without any improvement in ODI had < 0.36 kg (0.80 lbs) HER-L increase (Figure 8)
- Average GRC = +3.5 units; 95% of participants (18/19) reported improvement in overall functional capabilities

Table 1

Variable	Pre-Test Mean	Post-Test Mean	P-Value	Post - Pre Change	SRM	Post - Pre % Change
INV-R	4.30 ± 4.60	6.72 ± 8.43	<.001	+2.42	1.00	36%
INV-L	3.97 ± 5.70	6.72 ± 8.52	<.001	+2.75	1.53	41%
HER-R	3.77 ± 2.62	4.39 ± 2.69	.010	+0.62	0.66	14%
HER-L	3.57 ± 2.56	3.90 ± 2.26	.103	+0.33	0.39	8%
WSH-R	17.75 ± 8.94	26.21 ± 13.66	<.001	+8.46	1.19	32%
WSH-L	15.72 ± 9.26	23.11 ± 11.57	.016	+7.39	0.61	34%
ODI	3.05 ± 5.05	1.47 ± 2.74	.028	+1.58	0.55	-
IKDC	90.80 ± 11.88	92.32 ± 10.31	.103	+1.52	0.39	-
FAAM	99.18 ± 2.04	98.52 ± 3.66	.360	-0.66	-0.22	-

Figure 6

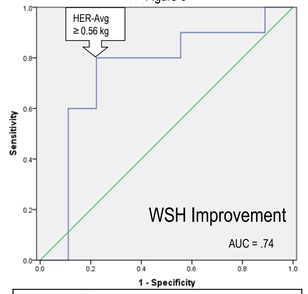


Table 2. WSH Improvement

Strength Gain	WSH ≥ 8 sec	WSH < 8 sec
HER ≥ 0.56 kg	8	2
HER < 0.56 kg	2	7
Total	10	9
Sensitivity = .80 Specificity = .78		
OR = 14.0 90% CI: 2.2 – 89.2		

Figure 7

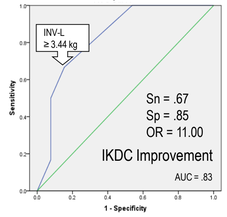
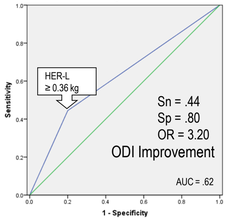


Figure 8.



CLINICAL RELEVANCE

- HER and INV measurements obtained from hand-held dynamometer demonstrated exceptionally good consistency
  - Use of stabilization belt appears to reduce variability of measurements
- Transverse plane strengthening program produced substantial improvements in multiple aspects of functional status
  - Standing Firm System® appears to provide a valuable exercise mode for improvement of multi-segmental function
- Improvements in both measures of muscle performance and survey-derived function scores suggests that transverse plane strengthening may provide an important contribution to optimization of core and LE dynamic stability

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