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AGE RELATED CHANGES IN LOWER EXTREMITY COORDINATION PATTERNS IN FEMALE RUNNERS

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The aim of this study was to compare the coordination patterns of the lower extremity joints in older and younger females during running. The results of this study show that the older runners have maintained similar movement and coordination patterns to younger runners as a result of years of running experience. The results in this study could provide researchers and clinicians the information necessary to develop shoe wear and orthotic devices to reduce the risk of injury in specific populations.

KEY WORDS: injury, joint couple, vector coding, coordination pattern

INTRODUCTION: A basic understanding of running mechanics has been established by studying the movement of individual joints and segments, yet the cause of running injuries remains unknown (Bates et al., 1978; Hamill et al., 1992; Levens et al., 1948; Lundberg, 1989; Manter, 1941). An understanding about inter-segment/joint coordinative patterns while running may provide insight to injury risk in specific populations. The quantification of inter-segment/joint coordinative patterns can be done using a modified vector-coding technique where coordination patterns are presented by plotting mean phase angles over time (Chang, Van Emmerik, & Hamill, 2008). Four coordination patterns can be categorized using this technique: in-phase, anti-phase, proximal phase and distal phase. Where in-phase couples rotate concurrently in the same direction; anti-phase couples rotate in opposite directions; proximal phase couples indicate that only the proximal segment is rotating and distal phase couples indicate that only the distal segment is rotating (Chang, Van Emmerik, & Hamill, 2008).
When compared to males, female runners are reported to be twice as likely to sustain running injuries (Taunton et al., 2002). Differences in lower extremity structure between men and women have been suggested to lead to differences in running mechanics between genders possibly resulting in injuries (Ferber, Davis, & Williams, 2003). It has been reported in the literature that females exhibit greater peak angles in hip adduction, hip internal rotation and knee abduction while running. This may be attributed to greater reported hip width to femoral length ratio in females (Horton & Hall, 1989). Gender aside, older runners are more likely to sustain an injury than younger runners (Taunton et al., 2002). In a previous investigation differences in the coordination of the lower extremity were observed between older and younger male and female runners (Freedman Silvernail et al., 2013). As injury risk is greater in females, it is important to investigate the coordination in this group alone. Therefore, the aim of this study was to compare coordination patterns of the lower extremity joints during running in older and younger females.

METHODS: Ten older female runners (50.5±9.5 years; 1.64±0.09m; 59.3±9.3 kg) and ten younger female runners (23.5±5.5 years; 1.66±0.07m; 62.7±10 kg) were included in this analysis. All participants ran at least 16km per week. The older female runners average weekly reported distance was 36.6km and 36.5km for the younger female runners. Participants provided written informed consent. Reflective markers were attached to their hips, legs, and feet in preparation for data collection. Participants were asked to run overground across a 25m runway at 3.5 m/s (±5%). The runway was surrounded with a nine-camera motion capture system (Qualysis Oqus, Gothenburg, Sweden) with a force platform instrumented in the center of the runway. Velocity was monitored using photocells placed 6m apart on either side of the force platform. Participants ran while wearing laboratory supplied neutral running shoes. Kinematic and kinetic data were collected at 240 Hz and 1200 Hz respectively and processed using QTM software. Angles were calculated using Visual3D (Segment angle data was extracted for the thigh, shank, foot, rearfoot and forefoot during stance. A modified vector coding technique (Chang, Van Emmerik, & Hamill, 2008) was used to quantify the mean phase angles (MPA) of the coordination of the thigh-shank, shank-foot, and rearfoot-forefoot. Mean phase angles were averaged over early stance (0-33%), mid-stance (34-66%) and late stance (67-100%). Effect size (ES) calculations (Cohen, 1988) were used to determine differences in coordination between groups for each coordination pattern. A large effect was deemed to be >0.8, a moderate effect >0.5 and a small effect <0.3.

RESULTS: Coordination patterns for older and younger females can be referenced in Table 1. In the thigh-shank couple (Figure 1), there were moderate differences between older and younger females during late stance for the flexion angle coordination (ES=0.6). The older females flexed the knee with thigh flexion (MPA=10.6 °) while younger females flexed the knee with in-phase movement of both the thigh and shank (MPA=65.2°). There were moderate differences in the coordination of thigh and shank internal rotation during early stance (ES=0.6) between older and younger females. Older females moved with in-phase rotation of the tibia and shank (MPA=48.2°) while younger females moved with distal phase internal rotation of only the tibia (MPA= 76.3°). During late stance, moderate significant differences were observed between older and younger females (ES=0.5). Both older females and younger females moved with only tibial internal rotation. Older females exhibited a higher MPA (90.5°) than younger females (MPA=86.5°). This suggests that older females flex the knee with a small degree of thigh external rotation during distal phase internal rotation of the tibia. Large differences in thigh-shank adduction were observed in early stance (ES=0.8). Older females moved with anti-phase rotation of the thigh and shank (MPA= 142.5°) and younger females moved with distal phase rotation of only the tibia (MPA=111.7°).

Table 1:Coordination patterns in old and young females

Portion of stance	Segment couple	Old coordination pattern	Young coordination pattern
	Thigh-shank internal rotation	In-phase	Distal
	Thigh-shank adduction	Anti-phase	Distal
Early (0-33%)	Forefoot-rearfoot eversion	In-phase	Distal
	Thigh-shank flexion	Proximal	In-phase
	Thigh-shank internal rotation	Distal	Distal
	Shank-foot adduction	Anti-phase	Proximal
	Forefoot-rearfoot flexion	In-phase	In-phase
	Forefoot-rearfoot eversion	In-phase	In-phase
Late (67-100%)	Forefoot-rearfoot adduction	Distal	Anti-phase

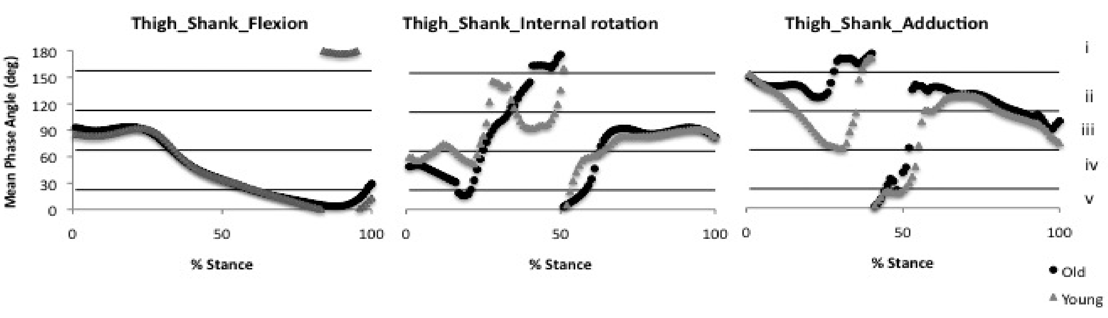

Figure 1. Phase angles for the thigh-shank couplings. i-proximal phase ii-anti-phase iii-distal phase iv-in-phase v-proximal phase.

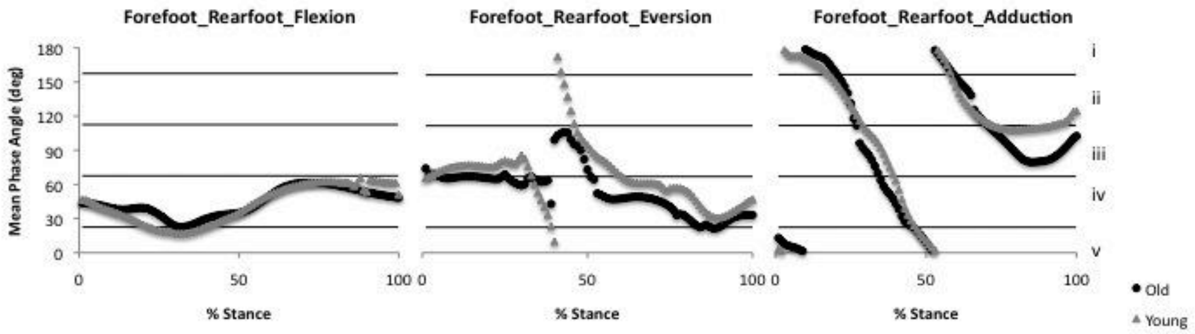

Figure 2. Phase angles for the forefoot-rearfoot rotations. i-proximal phase ii-anti-phase iii-distal phase iv-in-phase v-proximal phase.

In the shank-foot couple there were large age effects (ES=1.1) observed in late stance for the adduction angle coordination. Older females adducted the foot with anti-phase movement of the tibia and foot (MPA=143°) while younger females adducted the foot with only tibial rotation (MPA=157.7°).

In the forefoot-rearfoot couple (Figure 2) there were large age effects (ES=0.6) between age groups for the flexion angle coordination in late stance. Both older and younger females moved with in-phase coordination of the forefoot and rearfoot, however, younger females had a larger MPA (60.7°) than older females (MPA= 56.6°) which suggests younger females flex at the midfoot with a greater amount of relative forefoot flexion than older females. In early stance, there were large age effects (ES=1.4) between older females and younger females for the eversion angle coordination. Older females exhibited in-phase movement of the forefoot and rearfoot (MPA=66.6°) while younger runners everted the midfoot by only rotating at the forefoot (MPA= 76.4°). However, in late stance both older and younger females everted the midfoot with in-phase movement of the forefoot and rearfoot. Although both age groups exhibited in-phase coordination, there were moderate age effects (ES=0.7). Older females had a lower MPA (34.2°) than younger females (MPA= 48°) which suggests that older females evert the midfoot with a small degree of rearfoot rotation while moving in-phase with the forefoot. For the adduction angle coordination in late stance (ES=0.84) older females moved with only forefoot adduction (MPA=96.4°) and younger females adducted the midfoot with anti-phase rotation of the forefoot and rearfoot (MPA= 113.9°).

DISCUSSION AND CONCLUSION: The aim of this study was to compare coordination patterns of the lower extremity joints while running in older and younger women. By studying the rotations of the segments acting on the two ends of the tibia, insight may be gained on how the relative motion of the forefoot and rearfoot affect the relative motion of the thigh and shank. The results of this study show there are major differences in the coordination patterns of the lower extremity joints between older and younger female runners. Older runners exhibited anti-phase coordination patterns in the thigh-shank couple and the shank-foot couple in the transverse plane. Anti-phase coordination may be associated with increased risk to injury due to an increase of shear stress on the segments because they rotate in opposite directions. A more thorough understanding of the relationship between joint coordination patterns and injuries could provide a basis for the development of shoe or orthotic intervention strategies to target harmful coordination patterns and reduce the risk of running injuries in specific populations.

Despite significant differences between coordination patterns of older and younger female runners; older and younger female runners were observed to have the same coordination patterns in some cases. It is important to note that in such cases, the calculated mean phase angle provided further insight about how the two segments were rotating relative to each other since the coordination patterns were categorized based on a range of mean phase angles.

The females included in this study were trained runners. Therefore, the similarities of coordination phases between older and younger females may be due to the influence of training. It may be suggested that the older runners have maintained similar movement and coordination patterns to younger runners as a result of years of running experience.

Future research using larger prospective studies investigating joint coordination patterns in different participant populations could provide researchers and clinicians the information necessary to develop shoe wear and orthotic devices to reduce the risk of injury in specific populations.

REFERENCES:

Bates, B. T., James, S. L., & Osternig, L. R. (1978). Foot function during the support phase of running. *Running*, *3*(4), 24-31.

Chang, R., Van Emmerik, R., & Hamill, J. (2008). Quantifying rearfoot–forefoot coordination in human walking. *Journal of Biomechanics, 41*(14), 3101-3105. doi: 10.1016/j.jbiomech.2008.07.024

Cohen, J, Statistical power analysis for the behavioral sciences. 2nd ed. 1988, Hillsdale, N.J.: L. Erlbaum Associates. xxi.

Ferber, R., Davis, I. M., & Williams, D. S.,3rd. (2003). Gender differences in lower extremity mechanics during running. *Clinical Biomechanics (Bristol, Avon), 18*(4), 350-357.

Freedman Silvernail, J., Gruber, A. H., Rohr, E., Brueggemann, G., & Hamill, J. (2013). Age related changes in lower extremity segment coordination during running. *American College of Sports Medicine Annual Meeting,* Indianapolis, Indiana.

Hamill, J., Bates, B. T., & Holt, K. G. (1992). Timing of lower extremity joint actions during treadmill running. Medicine and Science in Sports and Exercise, 24(7), 807-813

Horton, M. G., & Hall, T. L. (1989). Quadriceps femoris muscle angle: Normal values and relationships with gender and selected skeletal measures. *Physical Therapy, 69*(11), 897-901.

Levens, A.S., Berkeley, C.E., Inman, V.T., Blosser, J.A., 1948. Transverse rotation of the segments of the lower extremity in locomotion. JBJS 30, 859–872.

Lundberg, A., 1989. Kinematics of the ankle and foot in vivo roentgen stereophotogrammetry. Acta Orthop. Scand. 233 (60), 1–25.

Manter, J.T., 1941. Movements of the subtalar and transverse tarsal joints. Anat Rec. 80, 397–410

Taunton, J. E., Ryan, M. B., Clement, D. B., McKenzie, D. C., Lloyd-Smith, D. R., & Zumbo, B. D. (2002). A retrospective case-control analysis of 2002 running injuries. *British Journal of Sports Medicine, 36*(2), 95-101.

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