KINETIC ANALYSIS OF AGILITY LADDERS DRILLS AND THEIR COMPARISON TO SPORT-SPECIFIC MOVEMENTS SUCH AS SHUFFLING AND SPRINTING

Brelynn S. Scoles [1], Maeve Sullivan, Megan E. Gold [1], Madison J. Blankenship [1], Hunter L. Frisk [1], Brian R. Biggs [1]

[1] Lakeland University

This study assessed agility ladder drills for the purpose of comparing kinetic characteristics of these drills to one another, and to sprinting and shuffling. Subjects (N=30) performed six agility ladder drills as well as sprinted and shuffled to the left and right over two large force platforms. A repeated measure ANOVA was used to assess horizontal and vertical ground reaction force (GRF) and the ratio of horizontal to vertical GRF, averaged from three steps for each drill. Significant main effects were found for all variables ($p \leq 0.001$). Post-hoc analysis identified differences ($p \leq 0.05$) between the agility drills as well as between the agility drills and the sprinting and shuffling. Results can be used to guide the progression of agility ladder drills based on known intensity and allow practitioners to prioritize drills that are most similar to sport-specific movements such as sprinting and shuffling.

KEYWORDS: running, sprinting, lateral agility, specificity, intensity

INTRODUCTION: Agility ladders have been recommended for improving a variety of athlete physical abilities (Myrland 2008; White, 2007). Training studies sought to assess the effectiveness of agility ladders (Padron-Cabo et al., 2020; Srinivasan and Saikumar 2012; Venturelli et al., 2008), though a contemporary literature review on the topic indicates that much remains uncertain (Afonso, et al., 2020). There has been no assessment of the kinetic intensity or potential for transfer of training of drills performed with agility ladders.

Agility ladders have been promoted to improve a variety of physical abilities such as kinesthetic awareness, balance, coordination, footwork, and agility (Myrland, 2008; White, 2007). Practical descriptions of drills and recommendations for the use of these devices have been published in coaching journals (Myrland 2008; White, 2007). Since then, training studies examined select aspects of the use of agility ladders.

Agility ladders were part of the training stimulus in the experimental groups of some research studies (Padron-Cabo et al., 2020; Srinivasan and Saikumar 2012; Venturelli et al., 2008). These studies showed that the experimental groups which included agility ladder training resulted in improved performance in 10 and 20 meter sprints (Padron-Cabo et al., 2020), 50 meter sprints, the SEMO agility drill (Srinivasan and Saikumar 2012), and sprinting with a soccer ball (Venturelli et al., 2008). In some cases, these improvements were no better than the control group (Padron-Cabo et al., 2020). It is difficult to draw conclusions since agility ladder training was only a part of the experimental group's training stimulus (Padron-Cabo et al., 2020; Srinivasan and Saikumar 2012; Venturelli et al., 2008), and the volume was not matched between the agility ladder training and other control or experimental groups (Srinivasan and Saikumar 2012; Venturelli et al., 2008). A literature review on the use of agility ladders indicated that the research is limited, the procedures poorly described, and most studies assessed unidimensional outcome measures. Thus, claims that the ladders improve agility cannot be substantiated (Afonso, et al., 2020).

Much remains unclear about the use of agility ladders as a training stimulus. The relative intensity of a variety of other training modes such as vertically oriented plyometrics (Ebben et al., 2011), horizontally oriented plyometrics (Kossow & Ebben, 2018), and sprinting and cutting (Ebben et al., 2016) have been established. However, no research has assessed the kinetic demands of agility ladders or the potential specificity of these ladder drills to athletic movements such as sprinting and lateral shuffling. Therefore, this study was designed to assess select kinetic variables of agility ladder drills for the purpose of comparing these drills to one another and to select sport-specific movement such as sprinting and shuffling. Results of this study will also allow for the comparison of these agility ladder drills to the kinetic demands of other previously investigated training methods such as plyometrics.

METHODS: Subjects included thirty women (age = 20.77 ± 2.14 years, body mass = 67.38 ± 11.18 kg, and height = 170.52 ± 8.18 cm). All subjects were NCAA Division III athletes and played a variety of sports including basketball, volleyball, soccer, and softball. Subjects with backgrounds in a variety of sports were purposely sought to increase external validity of the findings. All subjects provided signed informed consent and the study was approved by the governing Institutional Review Board.

Prior to the start of the research session, subjects performed a general, dynamic, and activity specific warm-up. Following demonstration and practice, subjects were tested in six agility ladder test conditions as well as during the standing sprint start (SSS), shuffling to the right (SR), and shuffling to the left (SL). The six agility ladder conditions included the forward one in (FOI), forward two in (FTI), lateral two in (LTI), lateral cross step (LCS), three count shuffle (3CS), and the three-count cross step (3CCS). These agility ladder conditions were recommended and described (Myrland, 2008), and are schematically depicted in Figure 1.

All test conditions were performed on two flush mounted force platforms (Accupower, Advanced Mechanical Technology, Inc., Watertown, MA, USA) deployed in series. The force platforms were calibrated prior to the testing session. Data were acquired at 1000 Hz and analyzed in real time with proprietary software (BP 6001200, Advanced Mechanical Technologies Incorporated, Watertown, MA, USA). All test conditions were randomized to reduce potential order effects associated with either fatigue or potentiation.

Peak horizontal/anterior GRF (HGRF) and vertical GRF (VGRF) were obtained, and the HGRF to VGRF ratios (H:V) were calculated based on the average HGRF, VGRF, and H:V from the first three steps of each agility ladder drill and for the SSS, SR, and SL.

Data were analyzed with a statistical software program (SPSS 28.0, International Business Machines Corporation, Armonk, New York). A one-way repeated measures ANOVA was used to evaluate the agility ladder drills and the SSS, SR, and SL, for each outcome variable. Bonferroni adjusted pairwise comparisons were used. The trial-to-trial reliability of the dependent variables were assessed using average measures intraclass correlation coefficients (ICC) and coefficients of variation (CV). The ICC were found to be > .60 and CV less than 10.0; thus, the average values were used for further analyses. The alpha level was set at $p \leq 0.05$ for all comparisons. Statistical power (*d*) and effect size (η_p^2) are reported, with effect size with thresholds of: small = 0.1, moderate = 0.3, large = 0.5, very large = 0.7, and extremely large = 0.9 (Hopkins, et al., 2009).

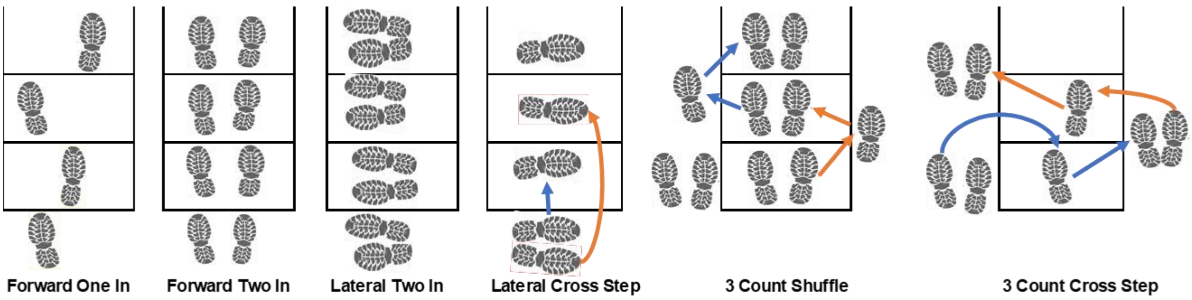

Figure 1. Agility ladder drills.

RESULTS: The analysis of HGRF revealed significant main effects ($p \leq 0.001$, d = 0.99, η_p^2 = 0.93). The analysis of VGRF revealed significant main effects ($p \leq .001$, d = 0.99, η_p^2 = 0.72). The analysis of H:V revealed significant main effects ($p \leq 0.001$, d = 0.99, η_p^2 = 0.92). Figures 1-3 show the results of the post-hoc analysis of the HGRF, VGRF, and H:V.

Average measure intraclass correlation coefficients for the dependent variables for each exercise test and load condition ranged from .73 to .99.

Table 1. HGRF (N) data expressed as means ± SD. N = 30.

Agility Ladder Drills	Sports-Specific Movements

3CCS[a]	LTI[b]	3CS[c]	FTI[d]	LCS[d]	FOI[d]	SL[e]	SR[f]	SSS[d]
81.01± 23.62	93.26± 20.97	96.22± 32.05	108.99± 30.08	162.95± 38.60	195.27± 40.02	222.13± 48.15	222.61± 39.84	444.02± 63.16

[a] significantly different ($p \le 0.003$) than all others except LTI and 3CS.
[b] significantly different ($p \le 0.05$) than all others except 3CCS.
[c] significantly different ($p \le 0.001$) than FOI, LCS, SL, SR, and SSS.
[d] significantly different ($p \le 0.05$) than all others.
[e] significantly different ($p \le 0.016$) than all others except SR.
[f] significantly different ($p \le 0.016$) than all others except SL.

Table 2. V-GRF (N) data expressed as means ± SD. N = 30.

Agility Ladder Drills						Sports-Specific Movements		
3CS[a]	LTI[b]	3CCS[c]	FTI[d]	FOI[a]	LCS[e]	SL[f]	SR[g]	SSS[h]
789.79± 155.48	1020.67± 155.46	1037.02± 196.53	1066.73± 148.22	1179.27± 161.08	1254.51± 227.09	1009.23± 171.38	1016.03± 165.53	1236.08± 171.79

[a] significantly different ($p \le 0.05$) than all others.
[b] significantly different ($p \le 0.05$) than all others except 3CS, LS, and RS.
[c] significantly different ($p \le 0.001$) than all others except FTI, LTI, Sl, SR.
[d] significantly different ($p \le 0.05$) than all others except 3CCS, SL, and SR.
[e] significantly different ($p \le 0.05$) than SSS.
[f] significantly different ($p \le 0.001$) than all others except FTI, LTI, 3CCS, and SR.
[g] significantly different ($p \le 0.001$) than all others except FTI, LTI, 3CCS, and SL.
[h] significantly different ($p \le 0.001$) than all others except LCS.

Table 3. H:V data expressed as means ± SD. N = 30.

Agility Ladder Drills						Sports-Specific Movements		
3CCS[a]	LTI[b]	FTI[a]	3CS[c]	LCS[d]	FOI[e]	SL[f]	SR[g]	SSS[e]
0.08± 0.02	0.09± 0.02	0.10± 0.02	0.13± 0.03	0.13± 0.02	0.16± 0.03	0.21± 0.03	0.21± 0.02	0.36± 0.04

[a] significantly different ($p \le 0.05$) than all others except LTI.
[b] significantly different ($p \le 0.001$) than all others except FTI and 3CCS.
[c] significantly different ($p \le 0.001$) than all others except LCS.
[d] significantly different ($p \le 0.001$) than the 3CS.
[e] significantly different ($p \le 0.001$) than all others.
[f] significantly different ($p \le 0.001$) than all others except SR.
[g] significantly different ($p \le 0.001$) than all others except SL.

DISCUSSION: This study is the first to assess biomechanic features of agility ladder drills and to compare these drills to each other and to select simulated sports-specific movements. Knowledge of the HGRF of the agility drills from this study allows for the progression of drills, as has been recommended (Myrland, 2008; White, 2007) based on the known intensity of HGRF. Results show that agility ladder drills such as the FOI result in 141% more HGRF than drills such as the 3CCS. However, the agility ladder drills demonstrating the highest HGRF are statistically lower than HGRF of sprinting and cutting in this study. The HGRF developed during the agility ladder drills ranged from approximately 81 N to 195 N. This level of kinetic demand is similar to several of nine horizontally oriented plyometric exercises assessed in previous research, where HGRF ranged from approximately 82 N to 345 N (Kossow & Ebben, 2018). The HGRF of plyometric exercises such as skips, cone hops, hurdle hops, and bounds (Kossow & Ebben, 2018) were all in a range found for the agility ladder drills in the present study. Thus, based on this variable, the intensity of agility ladder drills is similar to that of many plyometric exercises.

In the present study, compared to the HGRF, the mean VGRF were more similar between the agility ladder drills. Nonetheless, differences exist between some of the drills and allows for the progression of drill intensity based in this measure of kinetic intensity. In some cases, the agility ladder drills demonstrated similar VGRF to the SSS, SR, and SL, suggesting that these agility ladder drills may be more sport specific based on this measure.

The VGRF found for the agility drills and shuffling in the current study are lower than those found for subjects performing other sport-specific movements such as sprinting and transitioning to a shuffle or a cut, which demonstrated a mean VGRF of approximately 1553 N and 2255 N, respectively (Ebben et al., 2016). Other modes of training such as plyometrics demonstrated VGRF that ranged from 1052 N for exercises such as line hops to 2590 N for depth jumps (Ebben et al., 2011). This study (Ebben et al., 2011) included both men and women in the analysis, so potentially heavier men added to the magnitude of the VGRF values. Nonetheless, agility drills appear to have a kinetic intensity closer to plyometric line hops than other demonstrably higher intensity plyometric exercises (Ebben et al., 2011).

One training study described the specific agility ladder drills used (Padron-Cabo et al., 2020), which were similar to some of the drills assessed in the current study. Most training studies did not control for volume and used agility ladder drills in combination with other training strategies. These studies showed that the inclusion of agility ladder drills improved anteriorly oriented speed (Padron-Cabo et al., 2020; Srinivasan and Saikumar 2012; Venturelli et al., 2008), though none assessed lateral shuffling or other forms of agility other than the SEMO agility test (Srinivasan and Saikumar 2012).

Finally, the ratio of horizontal force developed during the agility ladder drills in the present study is substantially less than those developed during sprinting and lateral shuffling. Thus, these drills do not offer a stimulus that approximates the ratio of horizontal to vertical force demand of sprint starts and lateral shuffling.

CONCLUSION: Coaches and athletes should progress agility ladder drills by incorporating drills with higher kinetic demands over time. Drills should be prioritized based on those that most closely match the kinetic features of sport specific movements such as sprinting and shuffling. Agility ladder drills produce kinetic demands for variables such as the VGRF that are similar to many plyometrics.

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