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Situational Factors that Influence Overreaching on a Ladder during a Gutter Clearing Task among Older Adults

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Abstract

Ladder falls from overreaching are a problem in older adults. Evidence suggests ladder use behavior to be dependent on interfacing user and environmental circumstances (i.e. situational factors). This study investigates the effects of situational factors (remaining debris, ladder position, time into task, hand dominant reach, reaching disposition) on reaching during a gutter clearing task on a ladder in 104 older adults. Reaching was quantified as the maximum lateral center of pressure (COP) displacement from the ladder's center. A reach was classified as an overreach when the COP displaced outside the ladder width, indicative of a ladder tip. Reaching disposition, remaining debris, ladder position, and the interaction of reaching disposition and remaining debris predicted 20% of the reaching variability during the ladder task. Overreaching was observed in 40% of participants accounting for 13% of all extended reaches (beyond ladder). This work can guide interventions on mitigating overreaching and improving ladder safety.

Keywords

Ladder falls; Reaching; Decision Making

1. Introduction

Falls are dangerous in occupational and public health settings. Falls account for 40% of all injury deaths (Global) [1]. Approximately three-fourths of fall fatalities occur in adults aged 65 or older (13% of the population) (Global) [2]. Further, 29% of older adults report falling at least once a year (United States) [3], with 38% of fallers sustaining an injury. Falls for older adults occur across different activities, such as, walking and ladder use [4].

Falls involving ladders are a key source of occupational and public health fall injuries and are a particular problem for older adults. Fall injuries from a height lead to severe injuries [5] and cost approximately $6 billion of Worker's Compensation claims a year (United States) [6]. Ladder falls are the leading cause of falls from a height and the second leading

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cause of all falls accounting for 25% and 8%, respectively, in the workplace (United States) [7]. Nearly a quarter of ladder falls, both occupational and non-occupational, are categorized as serious with 14% requiring hospital stays greater than a week (Australia) [8]. Ladder falls are more dangerous for older adults, resulting in longer hospital stays, more ICU admissions, and greater fatality risk [8, 9]. Despite these risks, 61% and 96% of older adults report using a ladder at least monthly and yearly, respectively (Australia) [10].

Overreaching, reaching too far, is a common cause of ladder falls. Overreaching has been reported to cause 4% to 19% of ladder falls (Sweden and United States, respectively) [11, 12], and overreaching has been associated with 85% of ladder falls that occur while an individual is standing on the ladder (Denmark) [13]. Further, 37% of individuals who reported to the emergency department for a ladder fall identified overreaching as a contributing factor (Australia) [14], and 34% of older adult ladder users self-reported overreaching as a common ladder use behavior (Australia) [10]. Yet, few studies have investigated the factors that contribute to overreaching on a ladder or the individuals who are likely to overreach. Previous literature has determined motivation (i.e. the presence of a target) to influence reaching behavior on a step ladder [15], but this work focused on maximum volitional reach and did not measure reaching during realistic ladder use tasks. A key gap in the literature remains regarding factors that contribute to overreaching in realistic ladder use scenarios.

Emerging evidence supports that a combination of environmental and individual factors influence overreaching. Multiple facets of the ladder environment affect climbing safety on a straight ladder, such as, ladder dimensions [16], ladder inclination [17], and friction availability between the ladder feet and ground [18]. In addition to environmental factors, individual capacity in the areas of upper limb control, strength, balance, cognitive processing, and risk-taking affect task performance on a straight ladder [19]. In regard to reaching on a ladder, factors that are an integration of the individual ladder user with the environment affect reaching behavior. Specifically, reaching behavior on a ladder is known to be influenced by motivation of the task with potential effects due to task acclimation [15]. Thus, previous research suggests reaching on a ladder to be a complex behavior influenced by interfacing factors across the individual user and environment.

The purpose of this study was to quantify whether ladder tip risk due to reaching can be predicted by situational factors (interfacing user and environmental factors) during a gutter clearing task on a straight ladder. We hypothesized situational factors to predict reaching on a straight ladder during a gutter clearing task. Specifically, we thought a greater reaching disposition (ability and willingness to reach on a ladder), the presence of remaining debris, and a greater time into the task would be associated with farther reaches on the ladder. In addition, this study provides summary statistics on overreaching to better quantify this prevalence of this unsafe ladder use behavior.

2. Methods

One hundred and four participants enrolled in this study. Participants were eligible if they were 65 years or older, lived independently, and were willing to complete the ladder

climbing task (i.e. climb a straight ladder in a laboratory setting to clear a simulated gutter). Exclusion criteria included the use of a mobility aid inside the home, neurological disorders (e.g. Parkinson's disease, multiple sclerosis, dementia/Alzheimer's disease), a bodyweight above 120 kg (due to the ladder weight limit restriction), and the inability to complete the task due to pain. Ethical approval was obtained from the University of New South Wales Human Research Ethics Committee and all participants provided informed written consent prior to participating in the study.

The laboratory was outfitted with a roof gutter apparatus that was able to simulate a real roof gutter clearing scenario (e.g. cleaning leaves out of a one-story house gutter). The apparatus consisted of a 5.8 m length gutter filled with 64 tennis balls, where each tennis ball was separated by small dividers, 90 mm apart. The gutter was set at 2.1 m above the ground, representing the average height between the shoulder and elbow of a participant standing on the third ladder rung [20]. The ladder was a commercially available 2.7 m straight ladder with 29 cm spaced rungs. The ladder was attached to a sliding rail system and inclined at the recommended setup angle of 75.5° [18, 21, 22]. This sliding rail system allowed the ladder to be moved by participants in the medial-lateral direction. Specifically, the ladder was attached to the top and bottom rails via rollers that permitted lateral movement. Brakes between the ladder and bottom sliding rail system kept the ladder constrained while the participants were on the ladder [19]. These brakes limited lateral movement at the bottom of the ladder when active, constraining the bottom ladder-rail connection to pin joints. Lateral movement was not fully constrained at the top of the ladder (i.e. top ladder-rail connection constrained by rollers), permitting ladder tipping to an estimated 2 degrees, corresponding to 7 cm of lateral translation at the top of the ladder. The bottom of each ladder siderail (i.e. the ladder feet) was instrumented with a tension-compression loadcell (MLA22 Single Point Loadcell) to capture the ground reaction force of the ladder feet (sampled at 200 Hz). Video cameras captured the posterior and side view of the testing volume (sampled at 24 Hz).

Participants were asked to clear the tennis balls out of the gutter by dropping the tennis balls in a net below the gutter. To accomplish this task, participants needed to move the ladder across the gutter and climb the ladder multiple times. Participants were allowed to move and climb the ladder as often as necessary to clear the gutter. Participants were instructed to climb to the third rung (0.83 m above the ground) for each climb. Participants were told to complete the task as "quickly and safely as possible". Prior to starting the task, participants were given time to practice releasing the brakes and moving the ladder. The ladder was positioned in the middle of the gutter at the start of the task for consistency (e.g. gutter edges relative to participant arm span, decision to move the ladder to the left or right). After completing the gutter clearing task, the participants completed their farthest reaches while standing on the ladder. Participants were instructed "to reach as far as possible" to their left and right while standing on the third step of the ladder (farthest reach trial). Participants completed two farthest reaches to each side.

The primary outcome variable of this study was the ladder tip risk due to reaching, defined by the lateral center of pressure (COP) during the gutter clearing task. The COP was calculated from the vertical forces extracted from the loadcells beneath the ladder feet and the width of the ladder (Eq. 1)."

$$COP = \frac{R_{ZRB}x}{R_{ZLB} + R_{ZRB}} - \frac{x}{2} \quad \text{(Eq. 1)}$$

Where COP is the lateral distance travelled from the ladder center, R_{ZRB} is the bottom right vertical force, R_{ZLB} is the bottom left vertical force, and x is the distance between the loadcells. This simplified COP equation was supported in a model containing additional horizontal and vertical forces with the following assumptions: 1) The ratio of the vertical forces at the top and bottom rails were equal between the left and right sides (i.e. $\frac{R_{ZLB}}{R_{ZLT}} = \frac{R_{ZRB}}{R_{ZRT}}$); 2) 36% of the participant weight was applied in the anterior-posterior (AP) direction at the bottom rails [23]; 3) The horizontal forces in the AP direction on each side of the ladder are force couples (i.e. $R_{YLB} = -R_{YLT}$ and $R_{YRB} = -R_{YRT}$); and 4) There were no moments about the y-axis (i.e. in the frontal plane) and no medial-lateral force at the top ladder rails due to the support constraints of the pins and rollers (Supplementary Material 1). The maximum distance the COP travelled laterally away from the ladder's center and the timing of COP displacement is strongly correlated with the maximum lateral displacement of the hand (r = 0.53) and the timing of maximum hand displacement (r=0.96) during this gutter clearing task. Interpretation of reaching behavior via COP has advantages over hand displacement as the COP location reflects ladder tipping risk, regardless of individual characteristics (e.g. height, weight, arm span). Specifically, a COP farther from the ladder's center is associated with a greater ladder tip risk due to the COP travelling towards or beyond the ladder's base of support (i.e. the width of the ladder). Further, a reach was classified as an overreach in this study if the COP travelled outside the width of the ladder from the ladder's center (199 mm), which would have likely resulted in the ladder tipping if it was not constrained to the testing apparatus. The maximum COP was extracted and visually confirmed via synchronized video analysis for each reaching side after the participant climbed to the third rung resulting in a maximum COP for each side of each climb (Figure 1). Further, a participant was classified as an overreacher if they overreached at least once during the gutter clearing task and a non-overreacher if the participant never overreached. The number of extended reaches and the percent of reaches that were overreaches (% overreach) were recorded for summary statistics. An extended reach was defined by a minimum number of 5 tennis balls to the side of the corresponding ladder rail of the reach that would necessitate an extension of the arm. The % overreach was defined as the number of reaches classified as overreaches out of the total number of extended reaches. Data was excluded if both the force and video data were not fully accessible to calculate COP and visually confirm reaches. Data from one hundred and two participants was eligible for inclusion in our analysis (Table 1) (50 Women).

Situational factors were extracted from the gutter clearing task and farthest reach trials (i.e. factors that are inherent to user characteristics/decisions and the surrounding environment). Situational factors comprised percent of time into the ladder task (% time), ladder position, whether tennis balls to the side of the participant remained after completing tennis ball removal for that side and climb (remaining debris), if the reach occurred from the participant's dominant side (dominant side), and the farthest distance the participant was able and willing to reach when standing on the ladder (reaching disposition). The %

time was quantified as the percent time into the task from the start of the first climb to the end of the last climb (Figure 2.a, 2.b). This factor captures both user fatigue and their acclimation to the task. Ladder position was categorized into five locations of left, left middle, middle, right middle, and right with respect to the gutter (Figure 2.b). This factor captures the environmental constraints of the system and user placement choice. Remaining debris was categorized by whether there were tennis balls remaining to the side the participant was reaching towards or whether they had grabbed all the possible tennis balls to that corresponding side (Figure 2.a). This factor captures both debris availability and user risk-taking. Dominant side was categorized by whether the participant was reaching to their dominant side or not (Figure 2.a). This factor captures a user's spatial affinity. Reaching disposition was quantified as the peak COP excursion across the farthest reach trials. This factor captures the net effect of the participant's ability and willingness to reach on the ladder in this experiment's environment.

A three-level hierarchical regression was performed to determine the situational factors that best predict reaching during straight ladder use. The first level comprised a stepwise regression where situational factors could enter ($p<0.05$) or leave ($p>0.10$) the model at any step. The second level comprised a backwards stepwise regression with two-way interaction effects of the situational factors that entered the model after the first level. Interaction effects left the model if the p-value fell below 0.10. The third level comprised a forced entry of gender, height, and weight. The change in R^2 was recorded to determine if the entry of the parameter(s) at each step significantly improved the model. Individual linear regressions were performed on reaching to determine the individual strength and predictability of each situational factor.

3. Results

A total of 414 climbing attempts were analyzed. Out of a possible 828 reaching attempts (i.e. left and right reaching attempts for each climb), 579 extended reaches (i.e. reaches that extended to or beyond 5 tennis balls to the side of the corresponding ladder rail) were observed (Table 2). The average maximum COP was 0.086 m (± 0.085 m) across all reaching attempts, corresponding to a COP 0.113 m (4.50 inches) away from the ladder's tipping threshold. The average maximum COP was 0.106 m (± 0.085 m) across all extended reaches, corresponding to a COP 0.093 m (3.66 in) away from the ladder's tipping threshold. Of the 579 extended reaches, 76 were classified as overreaches (i.e. COP travelled outside the ladder's base of support). Forty-one (out of 102) participants had at least one of their reaches classified as an overreach. There were 11 overreaches when the ladder was positioned left (out of 98 extended reaches, 11.2%), 20 when positioned left middle (out of 109 extended reaches, 18.3%), 19 when positioned middle (out of 180 extended reaches, 10.6%), 24 when positioned right middle (out of 108 extended reaches, 22.2%), and 2 when positioned right (out of 84 extended reaches, 2.4%). There were 34 overreaches when debris (i.e. tennis balls) was remaining (out of 299 extended reaches, 11.4%) and 42 overreaches when there was no debris remaining (out of 280 extended reaches, 15.0%). There were 40 overreaches to the participant's dominant side (out of 312 extended reaches, 12.8%) and 36 overreaches to the non-dominant side (out of 267 extended reaches, 13.5%). There were 39 overreaches for women (out of 297 extended reaches, 13.1%) and 37 overreaches for men

(out of 282 extended reaches, 13.1%). The average reaching disposition from farthest reach trials resulted in a COP of 0.194 m (± 0.088 m), corresponding to a COP 0.005 m (less than one-sixteenth of an inch) away from the ladder's tipping threshold.

Three situational factors were found to be significant predictors of reaching in the first level stepwise regression. These predictors were reaching disposition ($F_{1,817}$=135.86; p<0.001), ladder position ($F_{4,817}$=3.81; p=0.005), and remaining debris ($F_{1,817}$=11.92; p<0.001). One of the interaction effects was found to be a significant predictor of reaching in the second level stepwise regression. This interaction effect was between reaching disposition and remaining debris ($F_{1,817}$=29.07; p<0.001) (Figure 3). The addition of gender, height, and weight significantly improved the model (change in R^2=0.01; p=0.029) (Table 3). The final model of reaching disposition, remaining debris, ladder position, reaching disposition*remaining debris, weight, gender, and height ($F_{10,817}$=21.22; p<0.001) predicted 21% of the variability in reaching measured by COP displacement from the ladder's center. (Figure 4) (Eq. 2).

$$COP\,[m] = 0.116 + LadderPosition + 0.311 * ReachingDisposition\,[m] + 0.011 * RemainingDebris + 0.140 * ReachingDisposition * RemainingDebris - 0.004 * Gender - 2 \times 10^{-5} * Height\,[mm] - 6 \times 10^{-4} * Weight\,[kg] \quad \text{(Eq. 2)}$$

$$LadderPosition = \begin{cases} -0.010 & if\ Left \\ 0.004 & if\ Left\ Middle \\ 0.006 & if\ Middle \\ 0 & if\ Right\ Middle \\ -0.016 & if\ Right \end{cases}$$

Units are represented in brackets for continuous variables. Nominal dummy variables are set to 1 when the condition is present and 0 when the condition is not present.

Individual regressions revealed statistically significant relationships between reaching and the % time ($F_{1,826}$=8.78; p=0.003, R^2=0.01) (Figure 5.a), ladder position ($F_{4,823}$=8.21; p<0.001, R^2=0.04) (Figure 5.b), reaching disposition ($F_{1,826}$=117.95; p<0.001, R^2=0.12) (Figure 5.c), and remaining debris ($F_{1,826}$=22.26; p<0.001, R^2=0.03) (Figure 5.d). Dominant side was not found to be significant in the individual regression ($F_{1,826}$=0.61; p=0.436, R^2<0.01).

4. Discussion

This study found situational factors (interfacing user and environmental factors) to influence reaching in a simulated roof gutter clearing task on a straight ladder in older adults. A greater ladder tip risk from reaching (i.e. maximum COP displacement) was positively associated with a higher reaching disposition, the presence of remaining debris, and central ladder positioning. These situational factors predicted 20% of reaching variability. 13% of extended reaches were classified as overreaches that would have likely resulted in the ladder

tipping in a real-world scenario. These overreaches belong to 40% of the participants in this study.

The effects of reaching disposition, remaining debris, and ladder position are consistent with past research. Reaching disposition was the highest correlated variable in the stepwise regression accounting for 12% of the variability in reaching. The association of higher reaching disposition (i.e. ability and willingness) with greater reaching during the ladder task is similar to reaching research at lower height levels [24, 25]. Individuals with greater reaching capability and greater perceived reaching ability perform farther reaches when standing at levels closer to the ground (0-0.23 m above ground level) [24, 25]. Remaining debris likely acted as a target, providing external motivation. External motivation via a target in previous ladder reaching research increased lateral reaching [15]. Interestingly, this work by DiDomenico et al. (2013) was controlled (i.e. target presentation controlled by the experimenter) and employed explicit instructions to reach farther [15]. The remaining debris in the present study was dependent on previous user behavior with the environment and the motivation was associated with a consequence (i.e. potentially taking longer to complete the task due to the addition of another ladder climb). The synthesis of these studies suggests that motivation to reach laterally can take multiple forms. The effect of ladder position on reaching is likely linked to the physical limits of the task in the left and right ladder positions that reflected shorter reaches than the central positions. The location of the debris (i.e. tennis balls) in the left and right ladder positions were closer to the ladder for at least one side due to the physical limits of the gutter. This finding aligns with past research that found a reduced target distance to decrease anterior-posterior COP shift [26].

The effects of time on ladder fall risk (i.e. ladder tipping risk due to COP displacement) is inconsistent with previous literature. The time into the task was found to have a weak correlation with reaching in this study. This result deviates from past results in which the risk of ladder injury increases with time into the work shift [27]. A likely explanation for this difference is the time scales across these studies. The present study task was completed in minutes, while the study by Arlinghaus et al. (2012) had a time scale of hours. Thus, the present study may not have captured fatigue effects on reaching.

Reaching disposition is a context-specific functional metric that is likely influenced by multiple individual domains (strength, balance, psychology status) and the environment (task, height, base of support). Functional reach is a common clinical metric that captures balance and stability in standing [28]. Functional reach is also related to multiple areas of strength with higher functional reach being linked to improved core strength and stability [29, 30]. Functional reach is limited by increased fear of falling [31]. Reaching disposition measured via farthest instructed reach on a ladder in this study deviated from the functional reach test due to the direction of reach (reaching disposition is lateral whereas the functional reach test is anterior), the ability to grab the ladder rails for support, the standing height the reach occurred from (reaching disposition was measured on a ladder whereas functional reach is measured at ground level), and balancing the body-ladder system rather than just the body. Multiple studies have determined that limits of stability are lower laterally than anteriorly [32, 33]. While not all participants grabbed the rails in this study, grasping support strategies can increase an individual’s stability limits [34]. The elevated standing height of

the third ladder rung also affects balance measures. Standing at an elevated height shorter than a meter has been found to decrease COP sway [35, 36], while greater heights of three meters and higher have been found to increase sway [37, 38]. The decreased base of support of the ladder rungs has also been found to affect balance with decreased rung depth corresponding to increased COP range [39]. Lastly, it is unclear how participants accounted for the tipping dynamics of the ladder when performing the farthest reach task. However, the relationship between reaching disposition and reaching during the gutter clearing task suggests the capture of some of the underlying mechanisms influencing ladder use and risk.

The impact of situational factors on reaching is complex and reflected by interacting situational factors. Reaching disposition and remaining debris had a significant interaction on reaching (i.e. maximum COP displacement). Specifically, reaching disposition increased with COP at over twice the rate when debris was remaining than when no debris was remaining. Reaching disposition was posited to capture the user's ability and willingness to reach while remaining debris was posited to capture their risk-taking and debris availability. The possibility for risk-taking led participants to reach farther, showing that willingness and ability played a greater role in predicting COP when risk opportunity was present. Past literature has found individuals with high balance confidence to reach farther than those with low confidence [40]. Our participants may be showing a similar relationship with confidence that becomes more evident when debris is remaining.

These results have practical applications as a farther reach was associated with a greater ladder tipping risk. Reaching during the task was found to increase with individual reaching disposition (ability and willingness). This indicates that users with a higher reaching capacity will be more likely to laterally tip a ladder. This knowledge can be used in interventions to mitigate overreaching in users with a higher reaching capacity. Reaching was reduced when the ladder was positioned to the outside due to the boundaries present at the ends of the gutter. This effect can be leveraged to reduce the temptation of overreaching on a ladder (e.g. reach limiting indicators). However, further research is required. The influence of remaining debris on reaching behavior is a safety concern for work tasks that extend across wide lateral areas. This concern is particularly applicable to clearing gutters, hanging elongated or sequential light fixtures, painting the exterior of a building, and other common ladder tasks where this motivation would be present. This further supports the need to limit workspace reaching.

This study has limitations. The experimental apparatus was based on a common real-world task, but some situational factors were specific to this design. Increased height is known to lower balance, as well as increase fear of falling [41], and only one height level was tested in this experiment. The ladder was also constrained to prevent the ladder from falling, which may have prompted participants to reach farther than they would have with an unconstrained ladder. The testing apparatus was limited to the collection of forces at the bottom rail of the ladder, yielding a COP and tipping threshold based upon only the vertical forces at the ladder feet and not all forces present in the system. This model was verified to be robust to the inclusion of additional vertical and horizontal forces with our model assumptions (Supplementary Materials 1). Some covariation existed between remaining debris, ladder position, and % time. This is due to the position of the ladder starting in the center of

the gutter and participants commonly completing their first climb with the ladder in that position. In this position, participants would have remaining debris to both sides as no balls had been removed prior to this first climb. Another limitation was that only a single reaching task was considered. Additional ladder reaching tasks need to be studied to determine if these risk factors generalize to other ladder use tasks (e.g. painting) and which are specific to gutter clearing. Such research can lead to broader interventions that target reaching factors across ladder uses. Further research is necessary to interpret the results of remaining debris as this factor was found to increase reaching, yet there was a higher percentage of extended reaches classified as overreaches when debris was not remaining.

5. Conclusions

Reaching was predicted by situational factors. Specifically, reaching disposition, remaining debris, ladder position, and the interaction of reaching disposition and remaining debris predicted 20% of reaching variability during a gutter clearing task on a straight ladder. The knowledge gained from this study may guide future reaching studies and assist in ladder safety interventions in the form of indicators to limit reaching in the workspace, heightened cautious behavior during ladder use with wide lateral areas or remaining debris, and targeting countermeasures to individuals with higher reaching capacity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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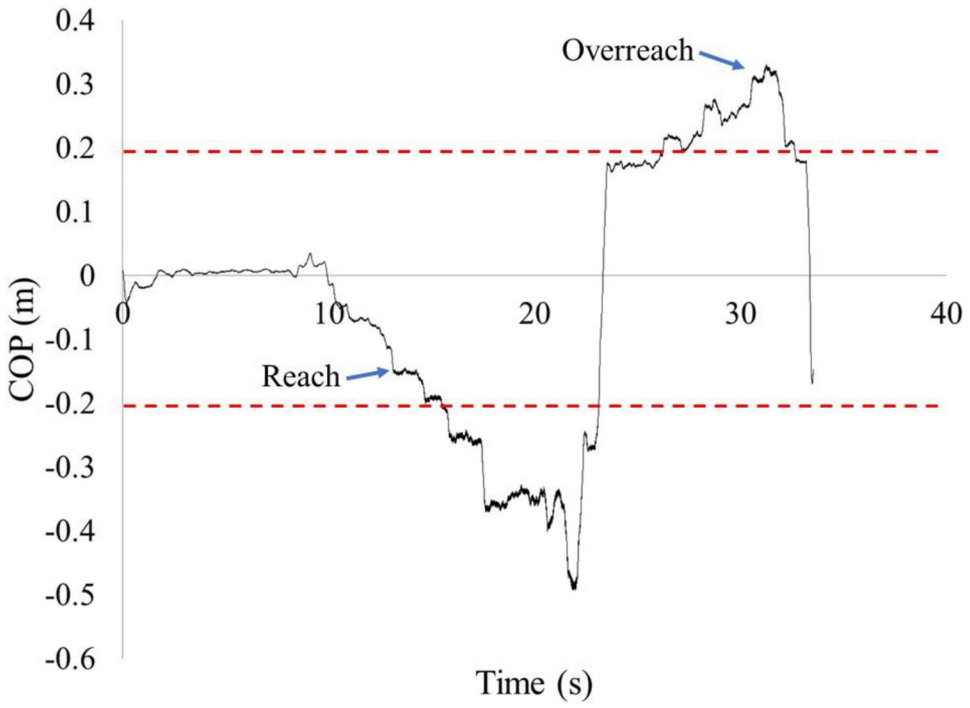

Figure 1:

COP trace throughout one climb with COP above 0 corresponding to left reaching and below 0 corresponding to right reaching. Zero corresponds to the COP location being in the center of the ladder. Reaches can be seen as the local minimum/maximum of steps in the COP data. If the minimum/maximum COP for each ladder climb and side during a reaching attempted exceeded the threshold of ± 199 mm, the reach was classified as an overreach.

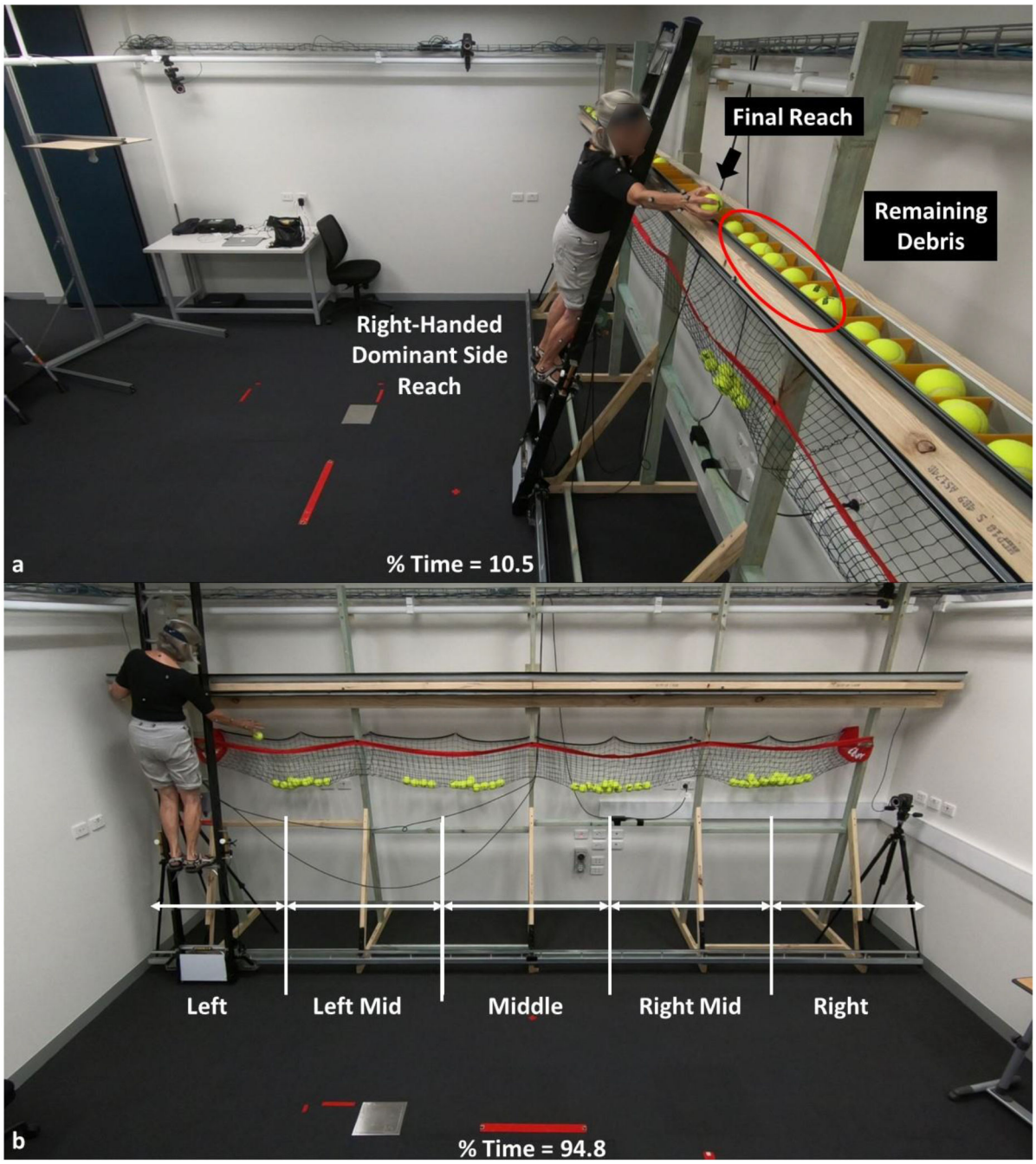

Figure 2:
Experimental apparatus highlighting the different situational factors of the gutter reaching task with **a)** showing remaining debris, a reach to the dominant side, and an early % time, **b)** showing a late % time and ladder position.

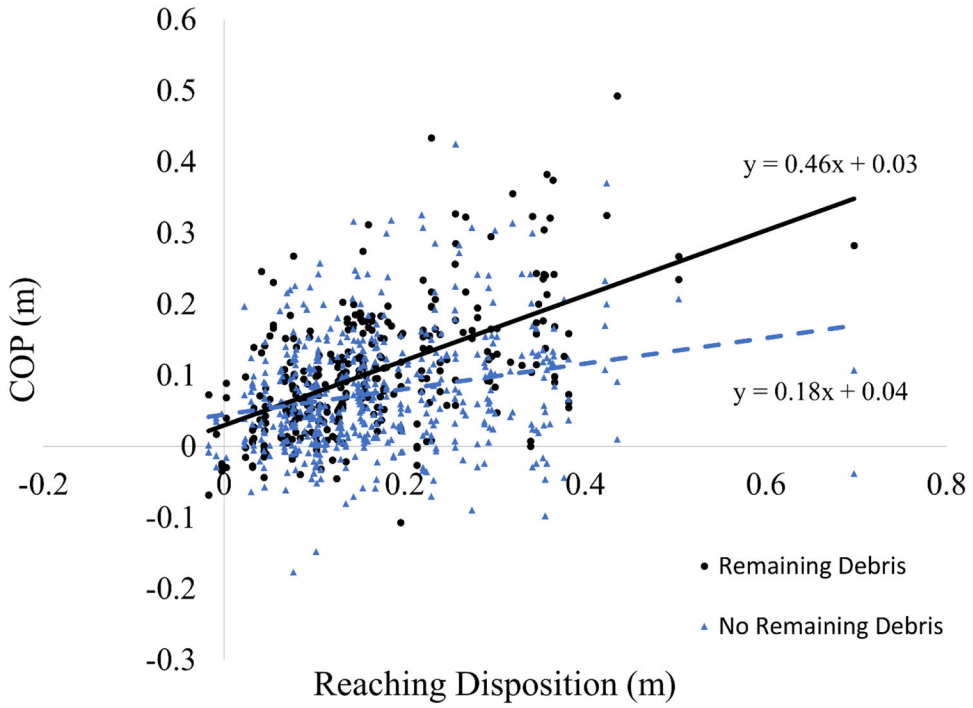

Figure 3:
Scatterplot of COP against reaching disposition for remaining debris (black circles) and no remaining debris (blue triangles). The equations for each line of best fit are displayed by the corresponding line.

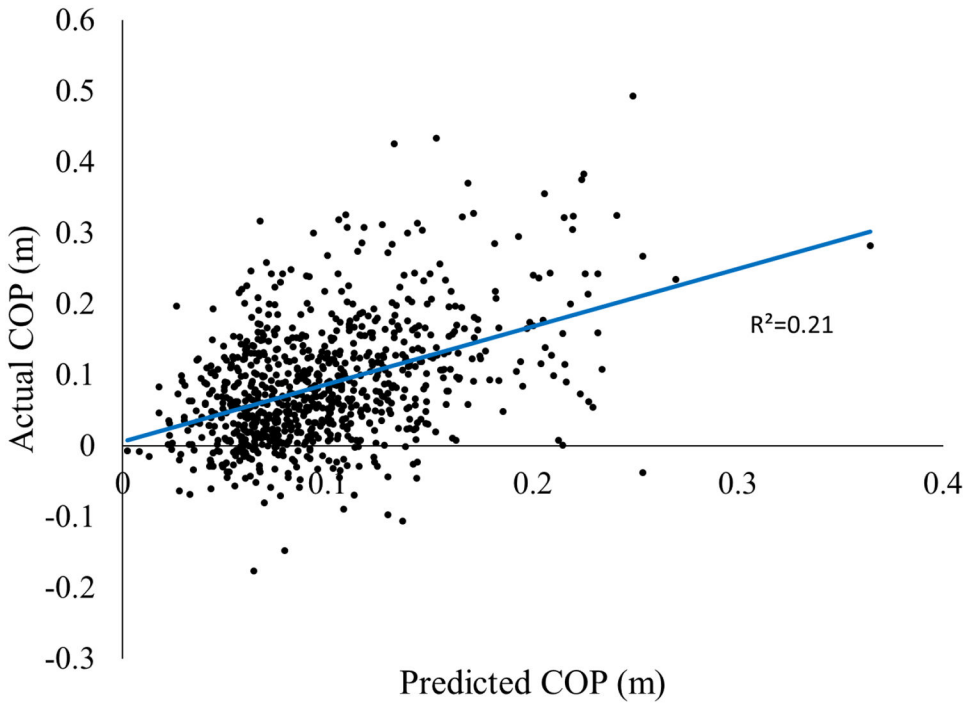

Figure 4:

The distribution of reaches between predicted COP and actual COP values. The blue lined denotes the line of best fit. The R^2 value denotes the variability of reaching explained by the model.

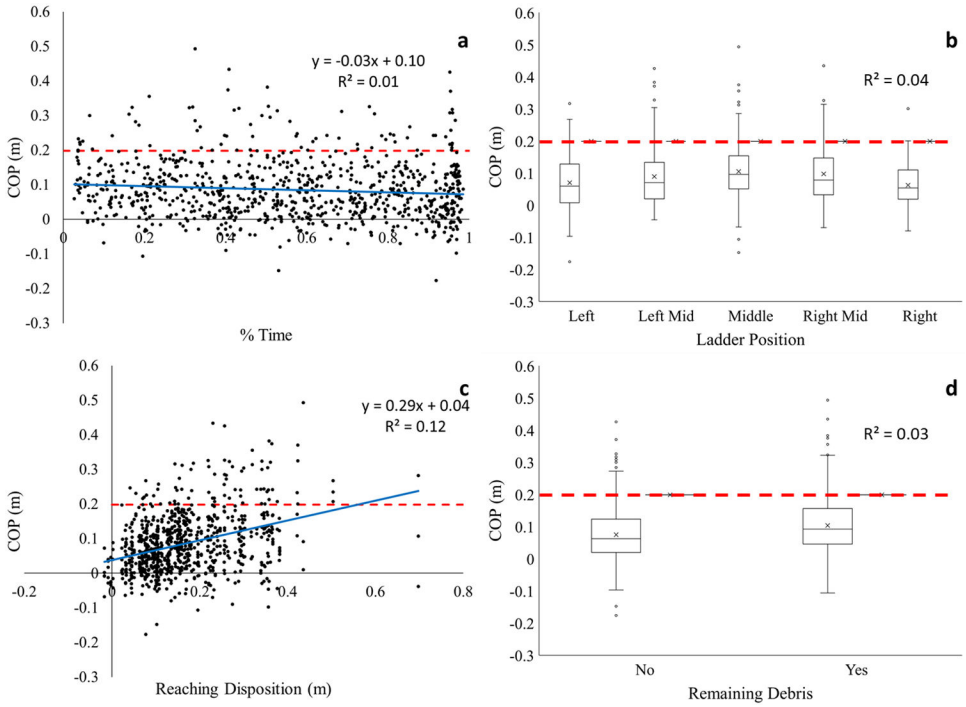

Figure 5:

Individual regressions for the significant situational factors of reaching including **a)** % time, **b)** ladder position, **c)** reaching disposition, and **d)** remaining debris. Each regression denotes the overreaching threshold of 199 mm with a red dashed line. COP values above the overreaching threshold are reaches that would have likely resulted in the ladder tipping if not constrained to the testing apparatus. Continuous measures include the line of best fit (solid blue line) and the regression equation from the statistical model. All plots include the reaching variability explained (R^2).

Table 1:

Mean participant characteristics for all the participants as well as each gender group.

Characteristics	Total	Men	Women
Age	72.90 ± 5.50	73.12 ± 5.66	72.79 ± 5.39
Age Range	65 - 89	65 - 89	65 – 87
Height (mm)	1700.41 ± 97.57	1767.44 ± 77.35	1633.39 ± 63.90
Weight (kg)	72.46 ± 13.35	79.32 ± 11.13	65.59 ± 11.84

Table 2:

Distribution of reaching attempts, extended reaches, and overreaches for each of the categorical factors in the analysis.

Categorical Factor	Number of Reaching Attempts	Number of Extended Reaches	Number of Overreaches	Percent of Extended Reaches that were Overreaches
Ladder Position				
Left	158	98	11	11.2
Left Middle	156	109	20	18.3
Middle	196	180	19	10.6
Right Middle	160	108	24	22.2
Right	158	84	2	2.4
Remaining Debris				
Yes	312	299	34	11.4
No	516	280	42	15.0
Dominant Side				
Yes	414	312	40	12.8
No	414	267	36	13.5
Gender				
Women	430	297	39	13.1
Men	398	282	37	13.1
Total	828	579	76	13.1

Table 3:

Situational factors that predicted reaching for a gutter clearing task on a straight ladder. The factors are listed in the step order they were entered into the model. The R^2 value is denoted after each step. The standardized β and t-statistic values are denoted for the final model. Ladder position β and t-values are referenced to the right-middle position.

Step	R^2	Variable	Standardized β	t-statistic
1	0.12	Reaching Disposition	0.39	11.66
2	0.15	Remaining Debris	0.13	3.45
3	0.17	Ladder Position [Left]	−0.07	−1.78
		Ladder Position [Left Middle]	0.03	0.70
		Ladder Position [Middle]	0.05	1.10
		Ladder Position [Right]	−0.11	−2.71
4	0.20	Reaching Disposition * Remaining Debris	0.17	5.39
5	0.21	Gender [W]	−0.04	−0.99
		Height	−0.02	−0.48
		Weight	−0.10	−2.31