Short Communication

# Effects of testing surface on performance time in a sled drag shuttle event

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***Objective***: To compare performance times of a sled drag shuttle event over natural grass, synthetic turf, and sand surfaces in order to determine if one surface consistently produces faster performance times than the others.

***Design & Methods***: Using a block randomized design, 25 active duty U.S. Army Soldiers performed one trial of the 250m sled drag shuttle event on each of the three testing surfaces; natural grass, synthetic turf, and sand. Total Event Time, Sled Drag Time and event time minus sled time (Event-Sled Time) were compared across the three surfaces. ANOVA with blocking and post hoc analysis were used to determine if there were significant differences in performance times between the three conditions. The alpha level was set at $p \leq 0.05$.

***Results***: Both Sled Drag Time and Total Event Time were statistically faster when performed on synthetic turf (0.31 ± 0.05 min and 1.40 ± 0.11 min, respectively; $p < 0.001$). There was no statistical difference in performance time when sled time was eliminated from the total event time ($p = 0.15$).

***Conclusions***: Testing surface does impact performance time in a sled drag shuttle event as performed in this study. If using such an event to assess and track physical performance or proficiency, it is recommended that subsequent testing take place on the same testing surface that was used for the baseline assessment. This will eliminate any performance advantages resulting from the varied testing environment.

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Key words: friction ■ synthetic turf ■ natural grass ■ sand

## INTRODUCTION

Pulling or towing a sled is an exercise that is often used to develop sprinting speed and power in athletes of various sports. The main purpose of resisted sprinting is to create a neuromuscular overload, resulting in increased training adaptations.[1] Such training is often carried out throughout different phases of a periodized program where the emphasis of the exercise may shift from developing explosive power over a relatively short distance (e.g. 5-10m) to increasing the athletes' stamina by pulling the sled over a slightly longer distance (e.g. 15-30m). It is over the longer distances that the friction of the surface may affect the performance.

Previous research has investigated the kinematics and kinetics involved with sled pulling performances. Such research concluded that sled towing resulted in altered step lengths, step frequencies and body angles which limited the transference of the training adaptations to sprinting performance.[2] Similarly, a study investigating the ground reaction forces required to pull sleds weighing 10% and 30% of body mass, found that the heavier sled (i.e. 30% body mass) required greater ground reaction forces in the horizontal direction than both the 10% loaded condition and unweighted sprinting condition[3]. While the friction of the surface was not directly assessed in these studies, as the weight of the sled increased, the direct application to an unresisted sprinting performance decreased. Additionally, as the weight of the sled increased, the amount of friction between the two surfaces would increase proportionally. This would result in a greater amount of force (both applied into the ground and on the strap of the sled) required to pull the sled. As such, the performance times when pulling heavier sleds would increase.

While previous research has used weighted sleds equivalent to a set percentage of the athlete's body mass, there has been little research investigating a set sled weight. When a set weight is used, the amount of surface friction during the towing event would be standardized across participants. Performances of the sled pull could then be compared across different testing surfaces to determine if a performance advantage is gained when performed on a specific type of surface. If a statistically significant advantage is found to be present, then standardizing the testing surface should be considered when performing multiple iterations of the assessment over extended periods of time (e.g. pre-season/mid-season/post-season, bi-annual fitness tracking, etc.).

Therefore, the purpose of the present study was to compare performance time of a shuttle sprinting event (inclusive of a sled drag leg) when performed over natural grass, synthetic turf and sand surfaces. It was hypothesized that performance time would be significantly affected by the various surfaces due to increased surface friction on both natural grass and sand when compared to that of synthetic turf.

## METHODS

### Participants

A total of 25 active duty U.S. Army Soldiers (21 males, 4

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females) volunteered to participate in this study. All participants were free of injury at the time of testing. Informed written consent was obtained from each participant prior to data collection. All procedures were approved by the United States Military Academy Human Research Protection Program.

### Experimental Protocol

Each participant performed a sled drag shuttle (SDS) event on three different testing surfaces; synthetic turf (FieldTurf® FTHD-1 synthetic turf), natural grass, and sand (baseball infield sand (approximately 75% sand, 15% clay, and 10% silt)). Participants were assigned to testing surface order using a block randomized design to account for familiarization effect as well as fatigue. Upon arrival to the designated testing surface location, participants' anthropometrics (age: 35.1 ± 5.9 years, height: 175.8 ± 6.9cm, weight: 81.6 ± 11.7kg, and leg length: 80.8 ± 4.5cm) were recorded. Participants then performed a standardized group dynamic warm-up prior to performing the SDS on the first surface. All participants were familiar with the task as they had performed it several times prior to this study. Therefore, no familiarization trials were taken by any participant. The following procedures were performed at all three testing surface locations with approximately 15 minutes of rest between trials.

Each of the 5 legs of the SDS event consists of a 25m sprint down and back, or 50m per leg and 250m total for the event (see Figure 1). Participants began by lying in the prone position on the ground with the head positioned at the start/finish line. On the researcher's command, the time was started and the participant stood up and immediately sprinted 1 leg of the course. Participants then grasped the handles of a nylon drag sled (Spud Magic Carpet, SPUD Inc., Columbia, SC, USA) loaded with 40kg (90lbs) and dragged it backwards for a second leg of the course. A second stopwatch was started when the sled crossed the start/finish line and was stopped when the sled completely crossed start/finish line following the 50m leg. This time was recorded as the *Sled Time*. Participants then began the third leg of the course by performing a lateral shuffle (or side-stepping motion) for 50m. Following the lateral movement, participants carried an 18kg (40lbs) kettlebell in each hand for the 4th 50m leg of the course. Participants then performed the final leg of the course by sprinting 50m. The first stopwatch was stopped when the participant crossed the start/finish line following the 50m sprint. This time was recorded as the *Event Time*.

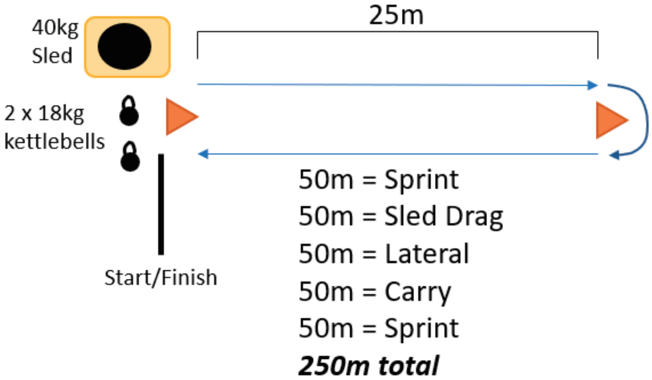


**Figure 1** Set-up for the sled drag shuttle (SDS) event

**Table 1.** Means and standard deviations (SD) for participants' performance times across each testing surface (synthetic turf, grass, and sand).

| | Sled Time (min) | Event Time (min) | Event- Sled Time (min) |
|---|---|---|---|
| Turf | 0.31 (0.05) | 1.40 (0.11) | 1.09 (0.08) |
| Grass | 0.37 (0.07) | 1.47 (0.07) | 1.10 (0.07) |
| Sand | 0.40 (0.08) | 1.48 (0.14) | 1.09 (0.07) |

### Data Analyses

For all comparisons, ANOVA with post hoc Tukey HSD was used. As each of the 25 participants were tested on each of the three surfaces (natural grass, synthetic turf, and sand), subjects were treated as a blocking effect accounting for the natural variability between participants. Analyses of interest included a comparison of 1) *Event Time* (i.e. total performance time of the 250m event) for each participant across surfaces, 2) *Sled Time* (i.e. performance time for only the 50m sled pulling potion of the event), and 3) *Event Time minus Sled Time*. Statistical significance was set at an alpha level of $p \leq 0.05$ throughout.

## RESULTS

There is strong statistical evidence that there was a difference in Sled Time due to surface (see Table 1). Sled Time performances were statistically faster on synthetic turf than grass ($p > 0.001$), while performances on grass were statistically faster than on sand ($p > 0.001$). Synthetic turf was also statistically faster than both grass and sand for Event Time ($p < 0.001$). However, there was no statistical difference in Event Time between grass and sand conditions ($p < 0.001$). When eliminating Sled Time from Total time, there was no significant difference in performance time between any of the surfaces ($p = 0.15$).

## DISCUSSION

Demonstrating proficiency in a variety of pushing, pulling and sprinting movements under varied loads (that may exceed body weight) is an essential component to the physical demands of many sports. Resources available to athletes may vary which may potentially affect their performance in such physical assessments. The current study investigated the performance times of the SDS event over three terrains commonly available to athletes: synthetic turf, natural grass, and sand. Performance times for both the sled drag portion and the entire 5-leg event in this study were fastest when the SDS was performed on the synthetic turf (0.31 ± 0.05 minutes and 1.40 ± 0.11 minutes, respectively) and slowest when performed on sand (0.40 ± 0.08 minutes and 1.48 ± 0.14 minutes, respectively). There has been a paucity of research comparing the performance times of dragging a sled (i.e. moving backwards) across multiple surfaces as the majority of research in this area has focused on improving sprinting performance by towing (i.e. moving forwards) a load behind an athlete.[4] However, such research has also found a significant difference in towing performance times across varied terrains with differing loads, primarily due to the coefficient of friction associated with each surface. For example, a surface will have a greater impact on the sled (whether it is being towed or dragged) if it is softer, thereby allowing the sled to sink into the surface more as opposed to riding across the top.[5] This is most noticeable when comparing sand and grass or synthetic turf, which supports the first finding of the current study.

In the present study, when the sled was dragged across the sand, a portion of the sand would accumulate in front of the sled, adding to the load to be dragged and resulting in slower performance time, as evident by the significantly faster Sled Times on both synthetic turf and grass than sand. Additional research has concluded that when the weight of the sled exceeds 30% of the athlete's body weight, a greater amount of horizontal force into the ground is required.[3] As the weight of the sled in the current study averaged approximately 50% of the athletes' body masses, it can be assumed that a greater amount of horizontal ground reaction force was required when pulling the sled. Additionally, the amount of force required to overcome the added resistance of the sand gathering in front of the sled during that surface condition would have exceeded the horizontal force required for the grass and synthetic turf conditions. Therefore, performing the SDS event on sand will likely result in a significant disadvantage for athletes and is not recommended by the authors of this paper.

Performance time of the SDS 250m event was found to be significantly faster when performed on synthetic turf (1.40 ± 0.11 minutes) compared to both natural grass and sand (1.47 ± 0.07 minutes and 1.48 ± 0.14 minutes, respectively). This is likely related to the faster performance time of the 50m sled drag portion of the event when performed on synthetic turf. As the sled drag portion is the second leg of the event, there is the potential for an added benefit to performance as a result of immediate post-activation potentiation. Previous research has shown improvements in sprint time when performing a sled pull (75% of body weight) 4-8 minutes prior to a maximum effort unresisted sprint.[6,7] While post-activation potentiation typically includes a set rest period between events, there may be immediate benefits to performance as well. For example, by performing the sled drag as the second leg of the event, performance times for the remaining legs of the event may have been faster due to the immediate unloaded condition. However, this is speculation as post-activation potentiation was not directly assessed in the present study.

Interestingly, when the time taken to perform the sled drag portion of the event was removed from the event time, there was no significant difference in performance times between any of the three surfaces (1.09 ± 0.07 to 1.10 ± 0.07 minutes). When comparing both Sled Time and Event Time across testing surfaces, synthetic turf produced the fastest performance times. This is consistent with previous literature that has reported significantly faster performance time when sprinting on synthetic turf when compared to that of natural grass.[8,9] Therefore, it appears that the faster performances are directly related to sled time and the coefficient of friction associated with the surface.

It is important to note that while not assessed during this study, there may be differences in performance times throughout the testing session as a result of the testing surface being worn over the course of repeated performance trials. Additionally, several participants (i.e. less than 5 per surface) were noted as falling at least once while performing the sled drag portion of the SDS on both natural grass and sand surfaces. As a result, this would have increased their individual Sled Times and may have affected the average performance times for each surface. While the time taken during these falls or mis-steps was not recorded, it is interesting to note that none of the participants fell when performing the SDS on the artificial turf surface. This, in addition to the relatively small sample size, it is recommended that additional research with a more robust participant pool is needed to gain a more thorough understanding of the effects that varied surfaces may have on a sled drag shuttle event.

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## DISCLAIMER

The views and opinions expressed in this article are that of the authors and not an official position of the United States Military Academy or United States Army.

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