SHOVELING IN THE NAME OF SCIENCE.

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ABSTRACT:
The fitness level of a single person rescuer is the most important factor that increases an avalanche victim's survival. After examining 23 people for their experience with avalanche rescue and fitness level, findings showed having high levels of each helps lower shoveling time, but combined lower unburying time significantly. A 5,000 cc duffel bag buried more than one meter deep in a snow berm was unburied as fast as possible by a single person rescuer, across 2 levels of fines sans 3 levels of experience. A fitter person strategically shoveling raises the probability of survival by lowering the amount of time spent beneath the snow surface. Mortality rates from s study 20 years ago found that survival probability rates at 15 minute are 92%. The decline rapidly to only 30% at 35 minutes (Falk, 1998). Because of the difficult snow conditions, shoveling is known to be the hardest part of companion rescue. In a one meter burial it's estimated that 1,000 lbs of snow is moved (BCA video). This shows the importance of making sure your skills are where they need to be before going in avalanche terrain.

KEYWORDS Avalanche rescue, companion rescue, fitness, experience

1. INTRODUCTION

Companion rescue in the backcountry gives you the highest chance of survival when caught in an avalanche. Over the years locating avalanche victims have gotten easier and faster, making shoveling more important in the rescue.

Strategic shoveling results in higher survival rates for avalanche victims by lowering the amount of time they spend buried and improve workspace during victim recovery (Edgerly, 2007). Shoveling is hard work and timely. Fitness and experience are determining factors for the successfulness of a single person rescuer.

The goal of my study was to see if there as a difference in unburial time single shoveler avalanche debris across two levels of fitness and three levels of experience controlling for depth and density.

2. BACKGROUND

In companion rescue shoveling is the hardest and most time consuming part of the rescue process. Because companion rescue depends on people in the ski group, there is no consistency in fitness and avalanche rescue experience.

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These levels may limit the work rescuers are capable of doing. Edgerly's Strategic Shoveling technique (2007) and Genswein's V Shaped Conveyor Belt Method (2008) are widely taught on avalanche courses, but are primarily useful for shoveling technique or in group rescue.

Typical avalanche burials in the U.S. are 1.16 meters (CAIC) with debris unlike new or even settled old snow. The specific characteristics of avalanche debris depend on the hardness and moisture content of the snow. In dry snow avalanches, the typical densities of debris deposits vary between 200 – 500 kg/m³ (McClung & Schaerer, 2006). Densities vary within the deposit, but in general avalanche debris is referred to as 'wet concrete' and is hard to dig through.

2.1 SHOVELING

Specific shoveling techniques have been developed over recent years by Edgerly (2007). By starting down hill 1.5x burial depth of the victim the shoveler should work into the slope, rather that straight down to the victim. This gives a more workable area to move in, and isn't compressing the snow on top of the victim. Keeping the digging area wide will give the rescuer more work space making it easier to move the snow. Genswein (2008), found how the use of more people during a rescue using a "V shaped conveyer belt method" can minimize the unburial time, the. This distributes work across the group by having two jobs, a digger and movers, rotating often to keep fresh.

2.2 EXPERIENCE AND EDUCATION

Decision making/risk management comes from your level of experience. There has been an increase of avalanche safety courses offered throughout the country teaching more people to ski the back country safely. The American Institute for Avalanche Research and Education (AIARE) teaches different levels of companion rescue within their courses. Rescuers learn that extrication (shoveling) is the most time consuming part of the rescue and thus strategic shoveling is enforced. A common industry standard with avalanche rescue practice is to locate a single buried subject wearing an avalanche transceiver in 2 minutes, allowing for a majority of the rescue to be spent extricating the victim.

2.3 FITNESS

The mountains attract a wide range of recreationist in different fitness and experience levels. An assumption can be made that backcountry travelers are in decent physical condition because of the activities they participate in. The most common measures of physical fitness used by health professionals are cardiovascular fitness and muscular endurance. Cardiovascular fitness can be tested by the maximum amount of oxygen your body can use indicating the body's ultimate work capacity (VO2 max). An individual's heart rate can be used to estimate energy expenditure during physical activity, but is not a strong indicator of fitness. VO2 max is measured by getting the lungs to work as hard as they can. Your VO2 max is the maximum amount of oxygen you can shift through your lungs. As the body works harder the lungs draw on more oxygen to supply the muscles, and eventually the body will reach an exhaustion point where the lungs are working at their maximum. Since VO2 max could not be used by the lack testing equipment Cooper endurance run test to examine the rescuers aerobic endurance by the distance ran in 12 minutes.

Muscular strength is the ability of a muscle or muscle groups to generate maximal force. Muscular endurance describes the muscle's ability to exert successive sub-maximal force for a longer period of time. Muscular strength and endurance are measured with standardized physical tests; examples include repetition maximum tests or callisthenic exercises. These fitness measurements require a moderate amount of time commitment from the participants and preferably an access to exercise physiology laboratory. By using basic strength endurance tests, like max push-ups and curl-ups in one minute, you can get a basic fitness base line to assess their upper body strength endurance fitness level. These simple tests helped us compare subjects' muscular strength endurance to other rescuers as part of the fitness assessment.

In a companion rescue extricating the "victim" can be an exhausting task because you may be the only one on scene. An appropriate tool to measure the exhaustion level of the participants and how hard they are worked is the Borgs' "Rating of Perceived Exertion" (RPE) (Borg, 1998). Perceived exertion is how hard one feels like their body is working based on the physical sensations they experience during physical activity. This includes increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue. The RPE scale 6-20 has verbal anchors to correlate with exertion numbers, which made it an approachable method to use in this experiment.

3. METHODS

3.1 SUBJUECT RECRUITMENT/ APPROVALS

Alaska Pacific University Institutional Review Board and Risk Management Committee reviewed and granted permission to recruit human subjects for this study.

To recruit volunteers I sent emails to members/students of multiple groups and organizations, (Alaska Avalanche School, Students of APU, Alaska's rescue community), as well as word of mouth.

Public: Included mostly university students with very limited shoveling experience and average physical condition

Outdoor Studies Students: University student recruited from the roster of Alaska Pacific University Outdoor Studies who have taken at least one of the snow related courses. This group knows how physically demanding shoveling is and has developed efficient methods and represents average physical fitness level.

Fit Alaskans: Anchorage informal Nordic ski group, Only in Alaska (OIA). This group represented the already fit and strong population of skiers with a competitive attitude and basic knowledge of shoveling.

Professionals: Rescuers recruited from Alaska Mountain Rescue Group (AMRG) which represented a fit population with a strong professional attitude and a lot of experience in shoveling.
Subjects were screened for history of general health concerns, cardiovascular disease, low back pain in the previous year, and active musculoskeletal disease. The testing protocol was explained and demonstrated before testing, and all subjects were given the opportunity to stop at any time during the project. The analyzed data-set without identifiers of participants will be saved by the investigator for a possible future use.

3.2 MOCK "VICTIMS"

We used one meter long duffle bags (5000cc) that are filled completely with snow to give them a more realistic resemblance of a body.

3.3 STUDY SITE

Alaska Pacific University granted permission to use the snow berm at the end of a small parking lot. This provided an easily accessible, controlled site that had avalanche debris characteristics. It allowed us to test multiple people at a time, and was close to a fitness center for the fitness testing.

The snow berm had accumulated over the winter and originally was long, narrow and shallow depth. But after a large snow storm the pile was pushed into one large pile estimate 2.0-2.5 meters high. We had four shoveling lanes within the site. After each shoveler completed their test we filled the hole using snow from the back of the berm.

3.3A SHOVELING LANES

The probe was placed on the bag 280cm away from the starting point, no starting location was given as we wanted the shovelers to use their judgment. Wands were placed around the perimeter to show where the lane was, giving each lane about a 200cmx 280cm area. To randomize lane assignments, each shoveler picked a lane number from a hat. All the participants used Voile Telepro avalanche shovel, with a 38x25cm blade.

4. ACTUAL EXPERIMENT

The study will be conducted over a two month period, March-April; testing was three times a week witch allowed disturbed lanes time to settle before the next trial.

4.1 CLASSROOM SESSION

At the start of the trial a brief introduction was given to the project as well as the risks involved. To verify volunteers' ability to participate was how they answered the set of questions about their physical and medical condition. After filling out the paperwork, a watching brief video: "Strategic Shoveling with Backcountry Access", was shown that discussed effective shoveling tips to remember (Back Country Access).

4.2 SHOVELING TIME TRIAL

The object was for participants to recover the bag as fast and efficiently as they could. When at the study site instructions of where the lanes were given and any last minute questions were answered. Once ready, data recorders started their trial. All decisions on where and how to shovel were up to the shoveler allowing experience to be factored in. Recorders kept track of participants' heart rate by the minute, comments made and three different times of bag visibility throughout their trial.

4.3 FITNESS TEST

The fitness test was held in the APU Atwood fitness center after the shoveling time trial so that everybody had the same testing conditions as the rest. The test was comprised of max push-ups and curl-up done in 1min, and a 12min run Coopers test (distance ran over 12 minutes. The running was conducted on a treadmill. At the end of the run they were asked again to rate their Rate of Perceived Exertion, trying to get a relation between effort given between shoveling and running.

4.4 EXPERIENCE QUESTIONNIRE

To gain background information on how much experienced each participant had, we gave a questionnaire with questions regarding past avalanche training, how proficient they thought they were at rescue techniques, and what method they used for strategic shoveling.

5.DATA COLLECTION

5.1 SHOVELING TIME TRIAL

Shoveling lane and depth of the bag were recorded prior to shoveling. During the time trial three times were recorded: first sight of bag, 2/3 of bag uncovered, and bag completely removed. Data collectors, also monitored their heart rate every min. After completion shovelers were asked to rate their RPE, as well asked "What they would have changed (if anything) giving a chance to redo the test?" Densities from each shoveling lane were taken after each test on a vertical gradient every 30cm, using a 250cm^3 sample tray.

5.2 FITNESS ASSESSMENT

In order to evaluate shovelers I made categories which had point values assigned and depending on performance in each test categorical points were awarded. Cumulative points from all three tests placed participants into two categories, Moderately fit and Fit.

5.3 EXPERIENCE ASSEMENT

We used two methods to gauge shovelers experience:

1. The first method was a questionnaire on avalanche training, proficiency in rescue techniques, participation in "mock" avalanche rescue, and if they had learned/ practiced shoveling techniques shown in video. Point values 1-5 were awarded based on participants' answers point totals could range 1pt-11pts.

2. The second method was recorder observation on how participant dug during the test. (Starting distance away from probe and workable shoveling area) Cumulative points placed participants into three categories, Inexperienced, Moderately Experienced and Highly Experienced.

6. RESULTS

In the end 26 unburial times were recorded, excluding subjects if they were unable to complete a part of the test, and if the burial depth was less than 1 meter. After these exclusions 23 subjects were available to analyze. General Public represented 9 (39%), Outdoor Studies students 6 (26%), Only in Alaska fitness group 5 (21%), and Professional 3 (13%). Moderately fit represented 5 (21%), Fit 18 (79%). Inexperienced represented 8 (35%), Experienced 10 (43%), and Professional 5 (22%), ages ranging 19-59 yrs. 19 males and 4 females.

Common bag depths were 116±9cm ranging from 105cm -135cm. Densities throughout the snow berm differed throughout the study 474kg/m^3 ±46kg ranging 381kg/m^3 -553kg/m^3. Though overall the study site ensured that the data can be relevant to real avalanche debris.

Both fitness and experience significantly effected unburial time, ($F_{4,18}$= 5.47, p=.031. $F_{4,18}$= 3.73, p=.044.)

Mean Unburial time decreased as fitness increased; Moderately Fit= 24.34min ±3.04, Fit 12.26min ±1.41. (Fig. 1)

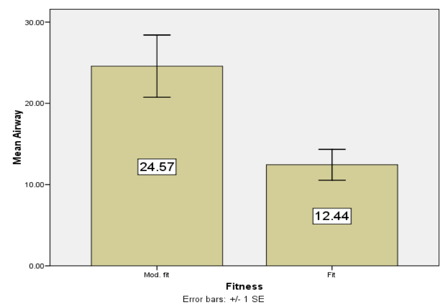

Figure 1: Show that as fitness increases unburial time decreases.

Unburial time decreased as experience increased: Inexperienced= 21.57min ±2.22, Moderately Experienced= 12.20min ±2.32, Highly Experience=9.37min ±3.08. (Fig. 2)

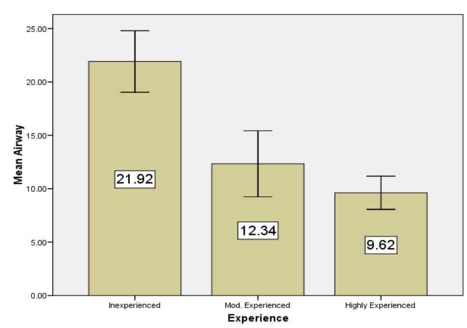

Figure 2: As experience increases unburial time decreases.

7. DICUSSION

In a single shoveler "mock" avalanche rescue fitness and experience significantly affected unburial time. Overall fitness leads to be the biggest factor in the shovelers ability to be efficient, having a 12min difference in unburial time. We found there to be a larger difference between Inexperienced and Experienced shovelers, than between Experienced and Highly Experience shovelers, showing that having some background in companion rescues significantly lowers time of unburial.

8. LIMITITIONS

8.1 LEVEL OF INTEREST IN THE STUDY

Because this study was looking at a hazard that only winter backcountry recreationalist would have, it was hard to convey the importance of the study to the "general public". For many volunteers strategic shoveling had a level of importance to them because they are regularly out in the avalanche terrain, so it had some higher level of importance to them. The lacking numbers in general population caused my moderately fit population to have fewer volunteers. Level of interest played a role in experience because backcountry recreationalist level of experience would not stop them from going in the backcountry.

8.2 STUDY SITE

Snow surface conditions varied throughout the study due to changing in temperatures and the reworking the snow with repeated excavations. A majority of the time all lanes had good quality to them (clean snow, consistent characteristics) though some lanes were better than others.

Lane A: Clean snow with fewer crusts forming a majority of the time. It had a low slope angle and was the most used of the four. Mean depth= 120 cm, mean density=457 kg/m³.

Lane B: Clean snow throughout most of the study got dirtier at the end, the length was very short 30cm from 280cm. The slope angle was small and was the second most used during the study. Mean depth= 113cm, mean density= 480 kg/m³.

Lane C: Dirty snow for the middle part of the study produced a thicker crust but was fixed by replacement of new snow. The slope angle was very steep making it a marginal lane, Mean depth=117cm, mean density=489 kg/m ³.

Lane D: Clean snow throughout the study. A slight sun curst formed near the end. Slope angle was very small. Mean depth= 116cm, mean density= 474 kg/m³.

One mistake was filling in the holes with snow that had been removed. This worked for a bit but over time got the snow became dirty when I dug down to deep. Dirty snow allowed the snow to melt faster and form thicker/harder crusts. We then switched to filling with clean snow. The largest problem was with the volume of snow in the lanes. When refilling we would get the correct depth, but the slope angle would be very steep, thus allowing for less snow to be moved for unburial.

8.3 DUFFEL PLACEMENT

All "duffel victims" were placed with the handles on top and laid as flat as possible. A few of the handles ripped while trying to be pulled out. This was due to the shoveler trying to remove the bag too soon. In a real scenario one would not be able to yank on the victim to get them out, instead you would have to remove all the snow around them. But the handles were needed here though for easier extrication of the "victim". There were three missed probed placements ±15cm, which falsely located the victim. Some shovelers kept digging until they located it and continued the extrication. Some missed probe placements left shovelers discouraged and they stopped upon first site of "victim".

9. CONCLUSION

Both fitness and experience significantly affect unburial time in a single shoveler "mock" avalanche rescue. This study suggests that you want a fit, experienced shoveler rescuing you. In future studies testing ski patrollers or the rescue community in multiple subjects unburials under the same factors.

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