

SHROOM TUMBLER GROUND REACTION FORCES

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ABSTRACT

Our clinic has two girls with congenital right transradial limb loss who use the Shroom Tumbler from TRS as their terminal device for competitive cheerleading. The younger of the two had complaints of discomfort in her arm when doing particular tumbling activities. Our objective was to understand what the forces were which were carried by the Shroom as compared to the forces in their sound hands.

The literature is sparse for hand to floor contact forces and we have found no reports for amputees. We have found that the range of observed loads in the hands and wrists of normally limed individuals doing things like back handsprings ranges from less than body weight to about four times body weight.

We used a 12-camera Vicon motion capture system with Kistler force plates to measure various floor exercises used in cheerleading, such as cartwheels and handsprings.

Initial tests showed high forces during tumbling activities. Subsequent changes to the prosthesis included a modified socket which improved her comfort level so that she no longer complains of pain in her sound limb and her prosthetic side. The socket, liner and distal end pads were customized to provide a total contact hydrostatic socket fit. This type of strategy provides a limb, socket interface that can withstand the high peaks in ground reaction forces and provides improved proprioception and stability for gymnastic/cheer activities.

The Shroom provides a good terminal device for cheerleading floor activities but using it should be coupled with coaching which understands the mechanics of the moves and proper form coupled with prosthetic care which can provide an optimal fitting.

INTRODUCTION

Our clinic has two girls with congenital right transradial limb loss who use the Shroom Tumbler from TRS as their terminal device for competitive cheerleading. The younger of the two had complaints of discomfort in her arm when doing particular tumbling activities during cheerleading. Our objective in testing them was to understand what the forces were which were carried by the Shroom as compared to the forces in their sound hands.

The literature is relatively sparse for hand to floor contact forces and we have found no reports for amputees. Penitente and Sands report some upper limb results and suggest that loads on the hands and arms should be considered "high" between 0.86 and 1.81 body weight (BW) for movements such as back handsprings. This is consistent with Davidson et al who report impact forces between 1.6 and 2.4 BW but are lower than Burt et al who report loads of up to 4 time BW in National and International level gymnasts. Thus this clinical study is, we believe, the first to measure ground reaction forces in upper limb amputees.

CLINICAL PROBLEM

The Shroom is very compliant when contact is made on the edge but is much stiffer if it is loaded axially along the arm.

In these types of prosthetic fittings the limb is axially loaded and subjected to high loading forces. Usually we think of an upper limb prosthesis as being subjected to distraction forces. However, in these fittings the upper limb fitting is treated more like the fitting of a lower limb prosthesis.

Tumbling activities happen very quickly and are hard to observe without motion and force capture technology. We have access to a 12 camera VICON motion capture system with force plates which was used to track the motion and record the forces through the hands and arms. Ages, height and weight are shown in Table 1.

Table 1: Information about the participants.

Participant	Age	Height (cm/in)	Weight (Kg/#)	Prosthesis
CD	7	124.5/49"	216N/48#	Right
EB	10	145/57"	477N/107#	Right
SH	11	144/58.5"	460N/103#	Nrm Limbs

The participants performed a variety of moves as listed in Table 2. CD is younger and at an earlier stage in learning moves and so had some moves which she did not perform. EB had injured her sound arm earlier in the year and was not comfortable doing Back Handsprings.

Table 2: Activities performed

Participant	Cart Wheels	Back Walkover	Front Walkover	Back Handsprings	Handstands
CD	Y	Y		Y	
EB	Y	Y	Y		Y
SH	Y	Y	Y	Y	Y

The measurements taken were primarily the forces recorded by the force plates for each of the participants.

We were concerned that for back handsprings and cartwheels, the forces for the younger girl were substantially higher than body weight, whereas the normally limbed participant and the older Shroom user kept their forces well below body weight.

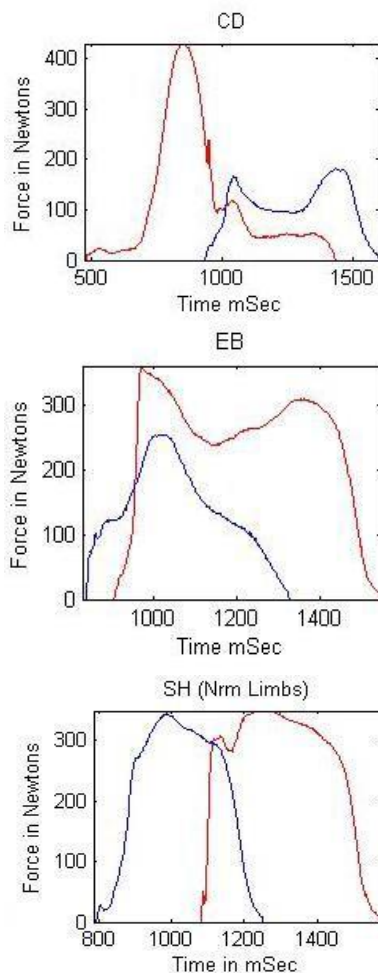


Figure 1: Cartwheels for the two Shroom users CD and EB and the normally limbed SH.

Back handsprings by the normally limbed individual and the younger Shroom user showed substantial differences. The normally limbed girl was very consistent and symmetrical with a maximum initial contact force more than double body weight (BW). The younger Shroom user experienced 4.45 times BW on

the sound side and 2.3 times BW on the prosthesis. There were very high loading rates for the prosthesis. The younger Shroom user's loading rates during back handsprings were as high as the normally limbed girl who weighs twice as much.

We had an experienced Cheerleader/tumbling Coach examine the data and videos of the testing session. She recommended changes in the training program and the use of more active spotting during potentially high force maneuvers such as back handsprings.

The prosthetist modified the socket used with the Shroom by making a custom silicone distal end pad. This child has an Ohio Willow Wood Spirit liner which is covered with a fuzzy pile fabric similar to Velcro. The inside of the socket had a patch of hook Velcro inserted which prevented the socket from rotating during vigorous Cheer activities.

The younger participant was seen again in October for a follow-up which provided the opportunity for a retest and another session with the cheer coach.

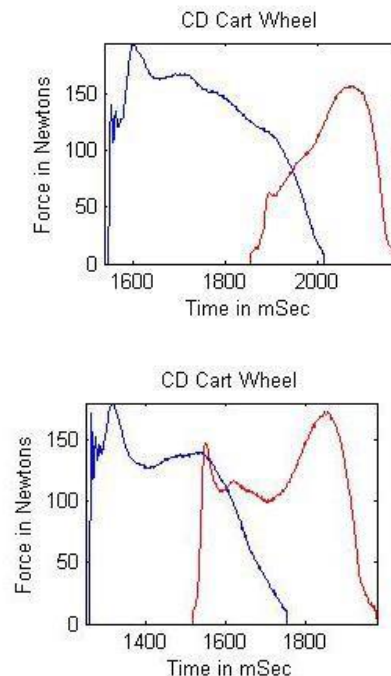


Figure 2: Typical cartwheels for CD during October visit.

As can be seen in the examples of cartwheels in figure 2, CD is no longer having very high loading during the activity. The sessions with the cheer coach have improved her arm positioning when doing many of the floor activities.

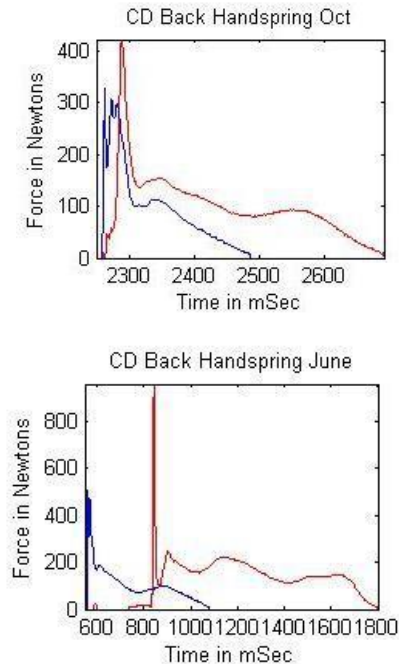


Figure 3: Back Handsprings in the June data collection at the top and for October on the bottom.

Note the very high June spikes. For October it is important to note that this was with spotting which would have reduced the forces to some degree.

In Figure 3 the other major change is that in June the prosthesis was landing well in advance of the sound hand while in October they were landing together which reduces the load on each side.

DISCUSSION AND CONCLUSION

Improvements to the prosthesis include the modified socket which has improved her comfort level so that she no longer complains of pain in her sound limb and her prosthetic side. The socket and liner and distal end pads were customized to provide a total contact hydrostatic socket fit. This type of strategy provides a limb socket interface that can withstand the high peaks in GRFs and provide improved proprioception and stability for gymnastic/cheer activities.

We have observed that the participants are not as consistent as we would have thought before doing the tests. There is a substantial amount of variation from move to move. The second set of cart wheels, however, never reaches the levels which were seen, and caused concern, initially.

The TRS Shroom provides a good terminal device for cheerleading floor activities but using it should be

coupled with coaching which understands the mechanics of the moves and proper form coupled with prosthetic care which can provide an optimal fitting for the activities.

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DISCLAIMER

This study used clinical standards of care, and was not a research study. All results and pictures report only de-identified data, unless informed consent was obtained.

This secondary analysis of data has been reviewed by the Research Ethics Board of the University of New Brunswick and is on file as REB 2017-059.