TITELSEITE

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# Biomechanics of a toss to hands in cheer sport

Biomechanics can generally be understood as “the study of the movement of living things using the science of mechanics” (Knudson, 2007). This broad field of interest can be sectioned in many different ways, Richard & Kullmer (2019) distinguish three domains: orthopaedic biomechanics, ergonomics/occupational physiology and sports biomechanics. This work is located within sports biomechanics, which includes analysis and optimisation of sport-specific movement technique, development, analysis, and optimization of methodological exercises, development and optimization of sports apparel and equipment, as well as prevention of injuries due to overtraining and unphysiological loads and stresses (Richard & Kullmer, 2019). The current study targets the analysis of sport-specific (here: cheerleading) movement (here: toss to hands) technique.

## Why is this necessary?

Apprehending sports technique might seem like a nerdy topic; however, it becomes quite relevant when approaching competitive sports. Athletes suffer higher injury risks when they train at a higher level. Meeusen & Borms (1992) concluded for gymnastics that with a higher level of performance, the difficulty of elements as well as the time spent practicing in the gym will increase evidently. They also refer to studies highlighting a “positive correlation between the time spent in the gym and chronic injuries” and “intensity as well as duration of training were identified as related to injury” (Meeusen & Borms, 1992). This very likely accounts for cheerleading, too. To lower these injury risks, appropriate technique and prehabilitation measures are substantial for (elite) athletes. But technique and prehabilitation both essentially require knowledge of the sport and its elements, especially for a sport as quickly advancing and developing as cheerleading.  
As currently most (if not all) elements in cheerleading are taught as have been taught, meaning a coach will only teach what and how they learned themselves, this study can be considered fundamental research in the field of cheerleading.

## The history of cheerleading / What is cheer sport?

With the rise of intercollegiate football games in the mid-1800s fans started chanting fight songs to cheer on their college team (Varsity Spirit, 2014; Grindstaff, 2015; International Cheer Union [ICU], 2018; USA Cheer, 2022). In November 1989 Johnny Campbell, a student at the University of Minnesota, was the first to enter the field organize the crowd in their chant – the first cheerleader (Varsity Spirit, 2014; International Cheer Union [ICU], 2018; USA Cheer, 2022). Until the early 1920s cheerleading grew to an all-male extracurricular activity, offered by high schools and colleges across the US (Varsity Spirit, 2014; Grindstaff, 2015; International Cheer Union [ICU], 2018; USA Cheer, 2022). In 1923 the first woman was allowed to join a cheerleading squad; however, it took 20 more years for female cheerleaders to not be an exception in cheer teams (Varsity Spirit, 2014; Grindstaff, 2015; International Cheer Union [ICU], 2018; USA Cheer, 2022). In these (and following) centuries cheerleaders expanded their skill set by adding tumbling and acrobatics to their routines, as well as props such as megaphones, signs, and poms (Varsity Spirit, 2014; International Cheer Union [ICU], 2018; USA Cheer, 2022). By now, cheerleading is predominantly female (90?% in Germany in 2021[[1]](#footnote-1)). Cheer sport is recognized by the International Olympic Committee (International Olympic Committee, 2022) and contains everything between side-line cheers and highly competitive athleticism. Today, cheersport unites all kind of disciplines that originate from organised groups cheering on certain sports teams. This includes but is not limited to:

* sideline teams: slow/static acrobatics paired with claps, motions, and chants, usually affiliated with a football team.
* competitive teams: practicing with the main goal of skill acquisition and competing at championships; usually more fast paced routines and higher difficulty acrobatics and tumbling.
* dance teams: highest variety of disciplines from hip hop to pom dance with simple, smoothly executed tumbling and acrobatic elements.

This study refers for the most part to competitive cheerleading. Competitive Cheerleading is categorized by skill level (ranging from zero to seven), age (peewees, juniors, and seniors) and team composition (female-only teams called all-girl teams and mixed teams with up to four or more male athletes called coed). The combination of level, age, and team composition defines the division under which the teams compete against each other.

## The toss to hands

The toss to hands is one of the most basic however fairly technically difficult stunts in coed stunting. Coed stunting usually refers to a male base with a female flyer, where the base lifts the flyer into the air and catches them afterwards on their own.   
A toss to hands is a mounting element where the base tosses the flyer so they will land in the base’s hands, standing. Therefore, the base stands behind the flyer with their hands holding onto the flyer’s hips. The flyers’ hands grab the wrists of the base from above. The flyer then performs a squat jump, pushing off the base’s wrists. The base follows the movement of the flyer and extends their arms above their head before releasing the flyer’s hips. The base then catches the flyers feet, completing the movement by standing with the flyer’s feet in their hands at shoulder height.

## Current state of research?

# Methods

* Overall procedure

## Participants

In total 14 athletes (7 female, 7 male) participated in the underlying study. The participants’ ages reach from 22 to 35 (M=27.21, SD=4.14) years. All participants have been pursuing cheer sport for a total of 4 to 16 (M=8.64, SD=2.98) years, and have been familiar with the skill for 1.5 to 11 (M=8.64, SD=3.04) years. The participants joined in already existing pairs or have been paired up by the instructor when joining individually. For further information about the participants age and experience separated by position see Table 1 below.

Table 1: Participants

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Position** | Age |  | Cheerleading experience [years] | Toss to hands experience [years] |  |
| **Flyer** |  |  |  |  |  |
| **Base** |  |  |  |  |  |

Participation was attained through a public call by the instructor shared with contacts and social media. The participants have been informed about the procedures of data acquisition including video recording and their opportunity to step back from the current trial at any time. Each participant gave informed consent before data acquisition started.

## Marker Placement

A total number of 65 markers was used in each trial: 33 markers on the base, 32 markers on the flyer. Generally, the marker set used is based on the plug-in gait marker set promoted by vicon nexus. However, some marker positions (such was WRA/B, RASI, LASI and HEE) needed to be altered, to not disturb the normal motion sequence.

### Upper Body

Sources: Wu et al. (2005),

### Lower Body

Sources: Wu et al. (2002),

## Data Acquisition

## Judge recruitment

## Judges’ questions

# Results

## Quantitative results

## Qualitative results

# Discussion

* Combine quantitative and qualitative results

# Conclusion?

* Phrase qualities of a ‘good’ toss to hands

# Literature

1. CCVD statistik M/W? [↑](#footnote-ref-1)