2006

Motion Analysis of a Back Handspring

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MOTION ANALYSIS OF A BACK HANDSPRING

by

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A Scholarly Project
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Doctor of Physical Therapy

Grand Forks, North Dakota
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2006
This Scholarly Project, submitted by Sarah Knoll, Jaclyn Minar, Melissa Moos, in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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(Graduate School Advisor)

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(Chairperson, Physical Therapy)
PERMISSION

Title  Motion Analysis of a Back Handspring

Department  Physical Therapy

Degree  Doctor of Physical Therapy

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Signature(s)

Sarah Smith  Date 12/15/05

John Doe  Date 12/15/05

M. V. Moore  Date 12/15/05
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Many thanks to Red River Valley Gymnastics and all of the gymnasts who participated.

A special thanks also goes to family, friends, and classmates for all their support not only with this project but throughout PT school.
ABSTRACT

Purpose: The purpose of this study was to analyze the joint angles and segmental motion of gymnasts during a back handspring in a tumbling series. The difference in lower extremity motion of the individual gymnasts with different levels of experience was compared. Subjects: 13 gymnasts were recruited by gymnastics coaches at Red River Valley Gymnastics. Only subjects with qualifications of being competitive in USA Gymnastics program, varying in levels 5-10, were included. Subjects were required to be able to perform a tumbling series consisting of a round off, a back handspring, and a back tuck-salto on a floor exercise mat independently and in a safe manner. Instrumentation: An eight camera, Vicon Motion System was used for the motion capture and the Vicon Workstation and Polygon 3.0 software was used for analysis and the generation of the reports. Procedure: Prior to beginning the trials, each subject completed a warm-up, followed by a stretching routine. Thirty five reflective markers were placed on the specific bony prominences required by the computer modeling program. Each subject performed up to five trials of the tumbling series with up to a five minute rest period between each trial. Data Analysis: A side view picture was obtained of the initial contact and the second contact of the lower extremities on the floor from the best trial of each subject. The pictures were analyzed qualitatively for the anterior and posterior relationship of the hip,
knee, and ankle joint to one other, and to the different levels of the gymnasts.

**Results and Discussion:** In general the higher the level of the gymnast, the more ideal the relationship between the lower extremity segments. The more ideal relationship offered the gymnast better control and ability to obtain the desired motion to progress into the next skill being performed. The middle and lower level athlete’s segmental relationships were such that there was not as much control which probably leads to unnecessary body motions, increasing muscle activity, and thus decreasing desired motion to progress into the next skill being performed. In general, the higher level gymnast’s body position was closer to the ideal for receiving a higher score by gymnastics judges and the middle and lower level gymnasts had body positions that would normally relate to a lower score. **Conclusion and Clinical Implication:** It was shown that the upper level gymnasts tended to have hip, knee and ankle positions, relative to each other, that were closest to ideal as compared to the middle and lower level gymnasts. It was also shown that motion analysis can be effective in developing a teaching tool for coaches to promote ideal technique.
CHAPTER 1
INTRODUCTION

The USA Gymnastic program has progressive levels of competition based on gymnasts’ skills. As the gymnasts advance through the levels they are required to perform increasingly difficult tumbling series. The technique of the skills in the tumbling series has to progress with the gymnast as they move through the levels of competitive gymnastics, to allow for performance of higher difficulty tumbling. Research using motion analysis can be used to analysis differences in technique and aid the instruction of the proper execution of the skill.

The technique that is currently being taught for the most effective performance of a back handspring in a tumbling series involves both the initial contact of the lower extremities after the round off and the second contact of the lower extremities just prior to take off into the salto. The purpose of the lower extremity positioning at initial contact is to cause backward and slightly upward propulsion of the body that allows the body to arch backward and make contact onto the hands (Figure 1a). At initial foot contact the ideal position is for the hips to be posterior to the knees and ankles and for the knees to be as close to vertical over the ankles as possible. Some degree of ankle dorsiflexion is
necessary at this point to allow for an explosive contraction of the ankle plantar flexors to assist in the backward motion desired.

It is not advantageous for the knee to be extremely anterior to the ankle as this would cause a forward motion, on contact, with excessive dorsiflexion of the ankle instead of the backward motion desired. At this time, the hip joint is in the best position to propel the body backward and the hip is more posterior to help direct this backward motion.

For the second contact, the ultimate directional goal is in an upward and only slightly backward to create height for the salto phase of the tumbling series (Figure 1b). To achieve this goal, the hips should be anterior to the knees and the knees anterior to the ankles. This forward angle of the body, along with the backward momentum from the previous skill, will together produce the desired upward and backward motion. As the gymnast practices this skill, and their technique improves, you will see a decrease in hip and knee angles and an increase in dorsiflexion during the second contact as the angle of the body increases to a more forward position. In the first contact, as technique improves, there is also a decrease in knee flexion and hip flexion. However, since the goal of this contact is a backward motion, ankle dorsiflexion should decrease through practice. This technique is what most gymnasts are being taught about correct performance of a back handspring and is assumed to be the best way to perform the skill to achieve the highest score from the judging.
Figure 1. Ideal, initial contact (a) and second contact (b).
Problem Statement:
There is a limited amount of published data that documents the differences in technique between different levels of competitive gymnasts performing a back handspring in a tumbling series.

Purpose:
The purpose of the study is to analyze joint angles and segmental motion of gymnasts during a back handspring in a tumbling series in gymnasts with different levels of experience.

Significance of Study:
The data collected will provide information that can be used as a teaching tool for optimal performance of a back handspring during a tumbling series.

Research question:
Are there differences in joint angles and segmental motion of gymnast at different competitive levels during a back handspring in a tumbling series?

Hypothesis:
There are differences in joint angles and segmental motion of a back handspring in a tumbling series between levels of competitive gymnast.
Athletes are constantly looking for ways to improve performance of a particular skill and decrease injury. Motion analysis and biomechanical analysis has been used for over a century to study motion. Biomechanics is a field that applies mechanical principles to biological symptoms and biomechanical analysis is applied to motion analysis.¹

Motion analysis can be used along with EMG to see what muscles are working in a particular movement. Maffet, et al.² studied eight muscles active during a fast pitch softball throw in order to describe the phases of the throw and which muscles are active at each phase. The athletes were hooked up to EMG electrodes and two reflective markers were placed on the head of the humerus and above the lateral epicondyle². The results, based on the EMG and motion analysis findings, allowed the researchers to summarize the softball pitch, according to various phases and muscle activity².

Other researchers use motion analysis to describe how to prevent injuries. Kochhar³ studied four different martial arts maneuvers and the biomechanics of the neck and head region during execution. The purpose of the study was to identify potentially dangerous motion in the maneuvers. The authors concluded
that, based on the results of the motion analysis, certain martial art maneuvers can have an impact similar to a whiplash injury in a motor vehicle accident.³

Other studies used motion analysis to help improve performance of various skills. The results from these studies can be used to develop teaching tools for coaches and athletes. Homma and Homma⁴ studied highly experienced and less experienced synchronized swimmers performing the eggbeater. The study used three dimensional motion analyses to examine the technique with markers placed on the greater trochanter, knees, ankles, and toes of the swimmers⁴. The results of the study compared the differences seen in technique between the less elite and more elite swimmers and provided coaching tips for proper technique of the eggbeater kick⁴.

Motion analysis has also been used to study various physical activities including different skills in gymnastics. The main focus of most of these studies was to determine the best technique including angular motion and joint angles. The purpose may also include how to determine how these skills are judged during competition. Aspects of skills in gymnastics as well as other sports including landing strategies and angular momentum are important in making these determinations.

Gymnastics is considered a closed skill sport meaning that consistency and stability of a skill is likely to be more important than variability when it comes to competition.⁵ Gymnasts are judged upon internationally recognized standards when competing. Many factors affect how a gymnast will perform a skill. Good
performance of a gymnastics skill depends on the skill level of the gymnast, psychological factors, and anthropometric factors like height and weight.

Other factors like the elasticity of the track and the approach characteristics of the gymnasts also should be taken into account. To succeed in competition it is important that all parts of the body work together to complete a skill appropriately. This is hard to measure, and is judged by the position of the limbs, trunk, and head throughout the skill. Two important factors that affect successful performance during performance of a tumbling series are vertical velocity of the mass center and angular momentum at the mass center during take-off.

Several researchers have looked at optimal execution of different events in gymnastics. One such study by Gervias and Dunn studied the double back salto dismount from parallel bars, comparing performances by the same gymnasts. The purpose of the study was to identify the features of the skill that were most likely to be modified to complete a successful performance. What they hoped to provide was valuable and practical information for both coaches and athletes to develop training strategies to assist in learning the double back salto from the parallel bars. The results of their study showed that the best performances of the dismount involve the gymnasts increasing forward lean and hip and knee flexion at the bottom of the landing. They also concluded that the best performers also had increased vertical velocity but less angular momentum on the release from the bars. The authors concluded that this may seem
contradictory to current belief, but they cite other studies using motion analysis that have concluded the same thing.

Another study by Takei, Dunn, and Blucker\(^8\) observed the mechanical and technical differences between two groups performing on the Roche vault. Their study reviewed the forty-eight Roche vaults performed at the 2000 Olympic Games and compared the technique used between the high and low scoring vaults.\(^8\) Mechanical variables were compared to identify the differences in techniques between the high and low scoring Roche vaults. Training strategies for the effective learning of the vault was the major purpose of this study. The authors concluded that the highest scoring vaults occurred when the gymnast accrues enough vertical velocity and angular momentum at take-off to get the body to rotate in the post flight stage. During the process, the gymnast will lose some horizontal velocity and angular momentum, but that, in-turn, will help increase vertical velocity. This study stressed the importance of observing the skill from the start of the run up to the vault to the landing. There are several, well coordinated components that go into completing the vault and each can be analyzed to help the athlete compete most successfully.

The use of motion analysis can be effective in looking at the position of the gymnast’s body throughout the completion of a skill. Grassi, et al.\(^5\), studied nine skilled, competitive gymnasts to compare the consistency of each part of a backward flic-flac. Thirteen landmarks on the body were marked and analyzed to observe the differences in performance caused by differences in the spatial trajectories of the landmarks and differences due to velocity in the execution of
the technique. The results showed that as a group, the six women gymnasts performed the skill very similar to each other and have better control of their movement than the three men. The researchers also found a specific consistency between the ten repetitions that each gymnast performed. The hips and shoulders were found to be most consistent and the wrist being the least consistent. The decreased consistency of the wrist could be due to the balance the gymnast has to maintain when they land. All the weight is through the hands and the position they are in is related to the balance needed to maintain the handstand position while going into the next part of the skill.

Body size can affect the gymnast’s performance as well. Most competitive gymnasts are lighter and shorter as compared to athletes in other sports. Ackland, Elliot, and Richards studied differences in body size and their affect on rotational performance of a gymnastics skill. They found that although larger physical size means greater angular momentum at take-off, it does not necessarily transfer to higher angular velocity during the skill. Larger gymnasts have increased muscle strength in their legs which accounts for the higher angular momentum, but once the gymnast is up in the air, they are unable to improve flight time. It was also a conclusion of this study that gymnastics skills involving backward rotation are completed more successfully by gymnasts with smaller body size, but there is not as much difference in vertical or forward rotational activities. A smaller gymnast may have an advantage over larger gymnasts in competition, especially when it comes to skills involving backward rotation.
A gymnast also needs to be able to adapt to various factors before and during the completion of a skill. King and Yeadon\textsuperscript{6} looked at the ability to adapt to various internal and external factors and still perform a skill correctly. They specifically look at approach characteristics, elasticity of the floor, muscle activation timings, and muscle strength during the take-off and flight phases of a skill.

Motion analysis is used in many studies for various reasons. It can be used along with EMG to observe what muscles are active during a particular motion or it can be used to help prevent injury. Another common use of motion analysis is to study a particular skill or technique and use the results to develop a teaching tool for better performance. Gymnastics is a sport where this can be helpful for both the athlete and the coach.
CHAPTER 3
METHODS

Twelve female gymnasts volunteered for this study. All of the gymnasts were recruited at the Red River Valley Gymnastics Club in Grand Forks, North Dakota. The gymnasts were competitive in the USA gymnastics program, varying in levels from 5-10. All of the participants were able to perform a tumbling series consisting of a round off, back handspring, back-tuck salto on the floor exercise independently and safely. All of the gymnasts and their legal guardians signed a consent form to participate. The gymnasts were divided into 3 groups according to their skill level. The 3 groups were levels 9-10, 7-8 and 5-6. The gymnasts were measured for height, weight, leg length, and joint width. The ankle, knee, hand, wrist, elbow, and shoulder width were measured with a caliper. The physical characteristics along with the gymnasts' levels are shown in Table 1.

The gymnasts were required to perform 4 to 5 trials of the tumbling pass with a 5 minute rest period between the passes. Prior to the trials the gymnasts were required to complete a warm-up of a 2-minute run, 10 minutes of stretching and 3 practice tumbling passes. All trials were performed at the Red River Valley Gymnastics Center in Grand Forks North Dakota.
Table 1.
Physical characteristics and skill level of the gymnasts. All units of measurement are metric.

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The gymnasts’ tumbling passes were captured by motion analysis. The motion analysis system used was the Vicon Motion System (Vicon Peak, 9 Spectrum Pointe, Lake Forest CA 92630, USA 949-472-9140). The system consists of 8 Vicon MX40 cameras with 4.0 MegaPixel resolution (4 of the cameras had 17-35 mm zoom lenses and 4 of the cameras had 12.5 mm wide angle lenses), and 8 infrared strobes. The cameras were connected to 2 MX Net boxes and a MX Link. The Vicon Workstation software was used for motion capture. The Vicon Polygon 3.0 software was used for analysis and the generation of the report. A Dell PC with dual processor was used to run the software.

The cameras were set up around the floor exercise mat. There were 2 cameras on each side of the mat corners and 2 cameras on the side of the mat. All the camera calibration was done per manufacturer’s instructions. Figure 2 shows a diagram of the experimental set-up. During the tumbling passes, the gymnasts wore a dark colored leotard and reflective markers. The reflective markers were placed on bony prominences that were used to calculate joint angles by the software program. The marker set used was the standard Plug IN Gait Marker set supplied by the equipment manufacturer. A complete list of the marker locations is shown in appendix A.
Figure 2. Experimental Set-up of the cameras.
Prior to the start of collection, each subject maintained a static position in the center of the mat while being recorded. The markers were digitized, creating a static stick-man model. The subjects were then asked to perform the tumbling pass while they were being recorded. Upon completion of the tumbling pass, the stick-man figures were reviewed using the Workstation software. The stick-man figure was used to create a dynamic model. The dynamic model was then loaded into the Polygon software and a report was generated showing a skeleton model of the hip knee and ankle angles. Each pass was cropped on the computer to just include the back handspring. This was determined to be when the feet hit the mat after the round off till the feet hit again at the beginning of the back-tuck salto.

For the purpose of the study, the relationship between the hips, knees and ankles from a side view was compared to the “ideal” standard stated earlier. The individual gymnasts were placed into groups according to their competition level. Trends were assessed between the levels and then compared to the other group levels. All comparisons and trends were made qualitatively rather than quantitatively, by a USA gymnastics coach.
CHAPTER 4
RESULTS

Qualitatively the study showed that, in general, the higher the level of the gymnast, the more ideal the relationship between the lower extremity joint segments. The hip was more posterior to the knee and the ankle and the knee was closer to vertical above the ankle on the first contact. On the second contact the hips were anterior to the knee and the knee was anterior to the ankle. This more ideal relationship offered the gymnast better control and ability to obtain the desired motion to progress into the next skill being performed.

The middle and lower level gymnast's segmental relationships were such that there was not as much control which probably leads to unnecessary body motions, increasing muscle activity, and thus decreasing desired motion to progress into the next skill being performed. The middle and lower level gymnasts showed a wide range of variation from the ideal with common variations being knees greatly anterior to the ankles and hips not posterior to the ankles of first contact and hips not being anterior to the knees on second contact.

We conclude that the higher level gymnast's body position was closer to the ideal for receiving a higher score by gymnastics judges and the lower level gymnasts had body positions that would normally relate to a lower score.
Figures 3 through 6 represent the higher level gymnasts who show a more ideal relationship between the hip, knee, and ankle joints. Figures 7 and 8 represent the middle level gymnasts who show deviation from the ideal position. Figures 9-14 represent the lower level gymnasts who show even greater variation from the ideal.
Upper Level

**Figure 3.** (a) The hips are in a good position posterior to both the knees and ankles. The knees are anterior to the ankle joints and directly vertical over the toes; the distance is not excessive and is close to the ideal. (b) Note the position of the hips anterior to the knees and the knees anterior to the ankles. This is a nearly an ideal position for assistance with upward propulsion needed for the next phase of the skill.
Upper Level

**Figure 4.** *(a)* Note the position of the hips directly superior to the ankles and the knees anterior to the ankles and toes. This position is good, however with a more desirable position would be with the hips and knees slightly more posterior. *(b)* This position of the hips slightly anterior to the knees and the knees anterior to the ankles is very close to ideal, however the hips should be slightly more anterior to obtain the ideal position.
Upper Level

Figure 5. (a) Note the hips directly superior to the ankles and the knees anterior to the ankles. This position would be closer to ideal if the hips and knees were positioned slightly more posteriorly. Also, the feet are not aligned in the frontal plane, which is less than ideal. (b) The position of the hips anterior to the knees and the knees anterior to the ankles is nearly the ideal position to facilitate the upward propulsion desired.
Upper Level

Figure 6. (a) Note the hips are directly vertical to the ankles and the knees anterior to the ankles. The position would be closer to ideal if the hips were more posterior to the ankles. However, the ankles are not well aligned in the frontal plane. (b) The position of the hips anterior to the knees and the knees anterior to the ankles is near ideal. Again the ankles are not well aligned with each other.
Middle Level

Figure 7. (a) The hips are posterior to the knees while the ankles are posterior and relatively directly underneath the hips. A more ideal position would be for the hips to be slightly more posterior to the ankles and the ankles aligned in the frontal plane. (b) Note the hip joint directly superior to the knee joint. This is an adventitious position with both joints being anterior to the ankle joint, however the hips being slightly more anterior to the knees would assist in the upward propulsion.
Middle Level

**Figure 8.** (a) There is an obvious, large amount of flexion in all three joints. This places the knees far anterior to the ankles and the hips nearly directly superior to the ankles. On contact this position would not assist in backward propulsion desired for movement into the next skill. (b) This position also shows a larger amount of knee flexion than is ideal which places the hips posterior to the knees and creates more ankle dorsiflexion than is desired for the upward propulsion into the next skill.
Figure 9. (a) Note that the hips are directly superior to the knees and the knees are anterior to the ankles. This position is not close to ideal and does not produce the backward motion desired into the next skill. (b) The hips being anterior to the knees and the knees being anterior to the ankle is close to the ideal position, however the total amount of forward lean is less than the ideal position desired to obtain the upward propulsion into the next skill.
Lower Level

Figure 10. (a) Note that the hips are posterior to the knees which is a good position, however the hips are anterior to the ankles which is not ideal for the backward motion desired into the next skill. (b) The knees are in a good position anterior to the ankles. The hips would be closer to ideal if they were more anterior to the knees. Also note that the knees and ankles are not aligned in the frontal plane.
Figure 11. (a) Note the hips are directly superior to the knees and both of these joints are anterior to the ankles. This is not ideal and does not assist in the desired backward propulsion into the next skill. Also note the feet are not aligned in the frontal plane.  (b) The knees are in a good position anterior to the ankles however, the hips would be in a more ideal position if they were anterior to the knees.
Lower Level

Figure 12. (a) Note that the knees are anterior to the ankles while the hips are posterior to the knees and slightly anterior to the ankles. This position would be closer to ideal with the knees and hips more posteriorly directed. (b) The knees are slightly more anterior to the ankles than the ideal position and the hips are also not in the ideal position being posterior to the knees.
Figure 13. (a) Note that the hips are posterior to the knees. The knees also show an anterior position as compared to the ankles. A more ideal position would be the hips being posterior the ankles. (b) The hips are posterior to the knees which is not an ideal position. The knees are anterior to the ankles, which is good, however they are more anterior than the ideal position.
Lower Level

Figure 14. (a) The hips are posterior to the knees and anterior to the ankles. A more ideal position is for the hips to be posterior to the ankles and knees, which are anterior to the ankles. (b) The position of the knees anterior to the ankles is close to ideal. The position of the hips would be more ideal if they were more anterior to the knees. Also note the feet are not aligned in the frontal plane.
CHAPTER 5
DISCUSSION

In gymnastics, stability and consistency are often more important than variability when performing a skill.\(^5\) There are certain characteristics that produce optimal performance of a back handspring in a tumbling series. As would be expected, qualitative analysis of this skill showed that upper level gymnasts demonstrate these characteristics better than middle and lower level gymnasts.

At first contact of the back handspring, upper level gymnasts were positioned with their hips more posterior to their knees, and their knees slightly anterior to the ankles. At second contact, this group contacted the ground with their hips anterior to the knees and the knees anterior to the ankles. In contrast, to the upper level gymnasts, the middle and lower level gymnasts were more varied in their performance. Some aspects of the skill resembled those of the upper level gymnasts and other areas were in need of improvement. This could be due to the fact that the middle and lower level gymnasts are continuously learning, improving, and gaining experience in the performance of the skill.

There were some limitations to the study. First, only thirteen girls participated with twelve of them being analyzed. Since a lower number of total participants meant a lower number of girls in each division (upper, middle, and lower), it was difficult showing obvious differences among the groups, especially
when comparing middle and lower levels. Another limitation of the study was that the results were based on qualitative analysis of the gymnast’s performance by a gymnastic coach. Finally, the results only included lower extremity performance of the skill. When performing the back handspring, all parts of the body, including the head, trunk, and limbs, have certain movement patterns that will lead to better performance. Total body results may have helped to show more differences between the different levels, particularly middle and lower levels. This limitation was due to inexperience of the researchers regarding the motion analysis equipment and placement of reflective markers and the ability of the software to model the motion.

Through the use of motion analysis, movement can be evaluated to help improve performance of a certain skill or prevent injury. In this study, motion analysis was used to determine what components of the optimal performance of a back handspring each gymnast possessed. The gymnasts were assigned to upper, middle, and lower level groups based on their levels according to the USA gymnastics guidelines. Differences amongst groups were qualitatively analyzed based on the results from the motion analysis. The results of the study were then used to develop a teaching tool for gymnasts and coaches about proper performance of a back handspring. Through this teaching tool, gymnasts can improve performance and prevent injury by learning the proper and safe technique of the skill.
<table>
<thead>
<tr>
<th>HEAD</th>
<th>PLUGIN GAIT MARKER SET</th>
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<tbody>
<tr>
<td>LFHD</td>
<td>Left Front Head</td>
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<tr>
<td>RFHD</td>
<td>Right Front Head</td>
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<tr>
<td>LBHD</td>
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<tr>
<td>RBHD</td>
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<tr>
<td>TORSO</td>
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<tr>
<td>C7</td>
<td>7th Cervical Vertebrae</td>
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<tr>
<td>T10</td>
<td>10th Thoracic Vertebrae</td>
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<td>CLAV</td>
<td>Clavicle</td>
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<td>Right Back</td>
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<td>ARM</td>
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<tr>
<td>R/LHEEL</td>
<td>Right/Left Heel</td>
</tr>
</tbody>
</table>

- **Acromion Clavicular Joint**: Midway between shoulder and elbow, placed higher on the right.
- **Midway between elbow and wrist, placed higher on the right**.
- **Lateral Epicondyle**.
- **Head of 2nd Metacarpal on dorsum of hand**.
- **Anterior Superior Iliac Spine**.
- **Posterior Superior Iliac Spine**.
- **Between the Greater Trochanter and Lateral Epicondyle, placed higher on the right**.
- **Between Lateral Epicondyle and Lateral Malleolus, placed higher on the right**.
- **Lateral Malleolus**.
- **2nd Metatarsal Head, on dorsum of the foot**.
- **Calcaneous, at the same level as toe marker**.
Plug-in-Gait Marker Placement

The following describes in detail where the Plug-in-Gait markers should be placed on the subject. Where left side markers only are listed, the positioning is identical for the right side.
Consent Form

As the Parent/Guardian, you are being asked to provide consent for your child to participate in a study conducted by Jaclyn Minar, Sarah Knoll, and Melissa Moos from the Physical Therapy Department at UND, under the supervision of their advisor, Thomas Mohr PT, PhD of the University of North Dakota, Department of Physical Therapy. The purpose of this project is to look at joint angles and segmental motion of gymnast's bodies during a back handspring in a tumbling series. We will be looking at the differences in these areas of gymnasts with different levels of experience. The results of the project will be used as a teaching tool for optimal performance of a back handspring during a tumbling series.

We are asking that you as a parent/guardian accompany your child where they will be asked to spend one hour of their time participating in the study. Each participant will be required to wear black spandex pants and shirt which will be provided for them. Reflective markers will be placed on specific bony prominences of each participant. The participant will be asked to complete a total of three trials of the same tumbling series; round off, back handspring, back tuck salto. Each trial will be recorded using a video camera and videocassette recorder. The data will then be analyzed and digitized and saved to a computer hard drive.

The possible risks from this study are potential injury due to the nature of the skill being performed. However no more risk will be acquired during this study than when performing this skill under normal practice conditions. No alterations will need to be made in the skills performance. The researcher, University of North Dakota Department of Physical Therapy, and Red River Valley Gymnastics will not be held liable for any injuries obtained during this study. The benefits which may result from this study are a potential teaching tool for gymnastics instructors. We cannot guarantee or promise that your child will receive any benefits from this study.

Any information from this study that can be identified with your child will remain confidential and will be disclosed only with your permission. All data and consent forms will be kept in separate locked cabinets for a minimum of 3 years after the completion of this study. Only the researchers, the adviser and people who audit IRB procedures will have access to the data. After 3 years, the consent forms will be shredded and electronic data will be erased.

Participation is voluntary, and your decision whether or not to allow your child to participate will not change your or your child’s future relations with the University of North Dakota Physical Therapy Department. If you decide to allow your child to participate, you are free to remove your child from the study at any time without penalty.
If you have questions about the research, you may call Jaclyn Minar at 701-740-3461 or Thomas Mohr PT, PhD at 701-777-2831. If you have any other questions or concerns, please call the Research Development and Compliance office at 777-4279.

You will be given a copy of this consent form for future reference.

All of my questions have been answered and I am encouraged to ask any questions that I may have concerning this study in the future.

__________________________
Parent/Guardian Signature

__________________________
Date
Assent Form

You are being asked to participate in a study done by Jaclyn Minar, Sarah Knoll, and Melissa Moos from the Physical Therapy Department at UND, under the supervision of their advisor, Thomas Mohr PT, PhD of the University of North Dakota, Department of Physical Therapy. The purpose of this project is to look at joint angles and segmental motion of gymnast’s bodies during a back handspring in a tumbling series. We will be looking at differences of gymnasts at different levels. The results of the project will be used as a teaching tool for best performance of a back handspring during a tumbling series.

We are asking you to spend one hour of your time participating in the study. You will be asked to wear black spandex pants and shirt which will be provided for you. Reflective markers will be placed on specific bony points of your body. You will be asked to complete a round off, back handspring, back tuck salto three times. Each trial will be recorded using a video camera and videocassette recorder. The data and pictures will saved to a computer hard drive.

There is no more risk of injury while doing this skill for our study than in a normal practice. The skill will be performed the same as it is in practice. The researcher, University of North Dakota Department of Physical Therapy, and Red River Valley Gymnastics will not be held liable/responsible for any injuries obtained during this study. The benefits which may result from this study are a potential teaching tool for gymnastics instructors. We cannot guarantee or promise that you will receive any benefits from this study.

Any information from this study that can be identified with you will not be shown to anyone without your permission. All data and consent forms will be kept in separate locked cabinets for a minimum of 3 years after the completion of this study. Only the researchers, the adviser and people who audit IRB procedures will have access to the data. After 3 years, the consent forms will be shredded and electronic data will be erased.

It is your choice to participate in the study, and your decision whether or not to participate will not change your future relations with the University of North Dakota Physical Therapy Department. If you decide to participate, you are free to leave the study at any time without penalty.

If you have questions about the research, you may call Jackie Minar at 701-740-3461 or Thomas Mohr PT, PhD at 701-777-2831. If you have any other questions or concerns, please call the Research Development and Compliance office at 777-4279.

You will be given a copy of this assent form for future reference.
All of my questions have been answered and I am encouraged to ask any questions that I may have about this study in the future.

Participant signature

Date_________________
REFERENCES


7. Takei Y, Dunn H, Blucker E. Techniques used in High-scoring and low-scoring 'Roche" vaults performed by elite male gymnasts. Sports Biomechanics. 2(2) 141-162.