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Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury in Physical Therapy and Occupational Therapy Students

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ASSOCIATION OF GENERALIZED JOINT HYPERMOBILITY AND OCCURRENCE OF MUSCULOSKELETAL INJURY IN PHYSICAL THERAPY AND OCCUPATIONAL THERAPY STUDENTS

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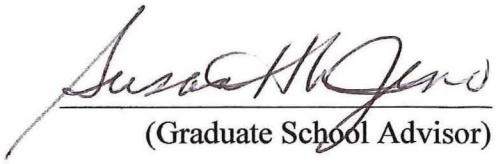
This Scholarly Project, which has been submitted by Allie Erdmann and Amber Klein in partial fulfillment of the set forth requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been thoroughly read by the Advisor and Chairperson of Physical Therapy under whom this work has been conducted and is hereby approved.



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Title	Association of generalized joint hypermobility and occurrence of musculoskeletal injury in physical therapy and occupational therapy students
Department	Physical Therapy
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Signature Allie Gilman

Amber Klein

Date 10-15-19

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

Background: Prior research has shown that physical and occupational therapy students have a higher prevalence of hypermobility than that which is seen within the general population. Throughout the literature, the rates of injury are greater in those with hypermobile joints. It has also been found that females have higher rates of hypermobility than males. Given this information, a secondary question arose regarding whether or not hypermobility and injury (initial or recurrence) are directly related to one another.

Purpose: The intent of conducting this study was to evaluate physical therapy and occupational therapy students for hypermobility while concurrently assessing for their previous injury history. The prevalence of both hypermobility and injury types were analyzed with the purpose of delineating a possible relationship.

Methods: A total of 35 subjects (13 male and 22 female) subjects volunteered and 34 were assessed for hypermobility using the nine-point Beighton Scale of Hypermobility. A score of four or higher out of nine indicated the presence of generalized joint hypermobility. Participants filled out a survey regarding current activity level, previous and current athletic participation, injury regarding type and mechanism of injury.

Results: It was found that 18% (6/34) were of the subjects were systematically hypermobile according to the Beighton Scale of Hypermobility. Of these, there were five females that were hypermobile (83%) and one male who was hypermobile (17%). Each participant reported sustained injuries in the following categories: sprains, strains/contusions, ligament rupture, fracture, and dislocation. Non-hypermobile persons were more likely to have had sprains and

dislocations. Participants with generalized joint hypermobility reported more strains/contusions and fractures. The most commonly hypermobile areas were found to be the elbows and thumbs. **Conclusion:** From the results of this study, it can be concluded that there is a difference in the prevalence of hypermobility between PT students in relation to the general public. PT students were found to have a rate of hypermobility of 18% in comparison to the 4-13% that the general public has. Injury rates were high among the sample used, with the most injuries coming from the ankles, fingers, and knees. The type of injury that was most prevalent was sprains. It can also be concluded that females are found to be more hypermobile than males. In future studies, it is recommended that a larger sample size is utilized in addition to physical therapy students, occupational therapy students, and the general public to allow for greater data analysis.
Keywords: prevalence; hypermobility, occurrence; recurrence; physical therapy; occupational therapy; students; injury

CHAPTER 1

INTRODUCTION

Scope of Study

This study focused on the prevalence of hypermobility and rates of associated injuries within a specific subset of graduate students in the physical therapy (PT) and occupational therapy (OT) programs at the University of North Dakota. This is a continuation of six previous studies conducted at the University of North Dakota.[1-6] The instigating study by Hestekin[1] found that the percentage of physical therapy students with systemic hypermobility was 21%. This figure is roughly three times that of the general public, the rate of joint hypermobility within the general public ranges from 4-13%.[7] Subsequent studies, Selinger et al[3] and Bisek et al[4], confirmed that PT and OT students have a higher rate of hypermobility than that of the general public with 32.6% and 39.5% respectively. The most recent study conducted in 2017,[3] reported a five times greater prevalence of hypermobility than the general population. All three studies were conducted within the bounds of the University of North Dakota, sampling from the PT and OT students present at the time.

Selinger et al[3] began to delve into the question regarding a relationship between types of musculoskeletal injuries and hypermobility of PT and OT students where shoulder dislocations were reported the most frequently. The most recent study by Bisek et al[4] replicated that of Selinger et al[3] but additional recurrence rates were researched. The data collected did not confirm an increased prevalence of injuries in those with hypermobility and it was noted that there is very minimal research regarding recurrence rates.[3]

As practicing clinicians, therapists are at an increased risk for injury at work given the physical nature of the job. Bork et al reported that a PT is most at risk for injuries in the following anatomical areas; the low back where a total of 45% reported symptoms, the wrists/hands where roughly 30% reported symptoms, and the upper back where almost 29% reported symptoms.[7] A therapist with hypermobility in conjunction with the physical nature of the job could experience an increased injury rate. Therefore, it is imperative to recognize hypermobility and instill the importance of preventative measures so a therapist can work effectively and safely.

Problem Statement

This study sought to determine the prevalence of hypermobility and its correlation with soft tissue injuries within the population of PT and OT students. Throughout the literature, there are discrepancies and inconsistencies that have been noted on this relationship in addition to the specific injuries that are related to usage of hypermobile joints; however, there is a definitive lack of evidence and research related to recurrence rates of injuries within the subset of hypermobile PT and OT students. In response to this, the following study will attempt to broaden the knowledge currently available and to impart reliable information regarding the soft tissue injuries that are related to PT and OT students who are hypermobile.

Purpose of Study

The intent of this research study was to evaluate the rate of joint hypermobility among PT and OT students. In addition, the frequency and type of injuries within the same subject population was researched for all subjects, hypermobile or non-hypermobile. The hypermobility of a subject was determined using the Beighton Hypermobility Scale. Within this scale, a score of 4/9 or higher indicated systemic hypermobility. The subjects who scored 3/9 or less were

classified as not being systemically hypermobile. The subjects score was used to compare with their previous injuries both in type and frequency. The second step was to determine if a relationship exists between one's hypermobility and injury history. This relationship was investigated for both systemically hypermobile subjects and those without systemic hypermobility. This study poses a clinical awareness portion as future clinicians ought to be aware of hypermobility and the associated risks. Should someone be found to be hypermobile, there are measures that can be undertaken to decrease and even prevent work related injuries. These measures include the usage of proper body mechanics and an understanding of the related risks to hypermobility.

Significance of Study

Six previous studies have indicated that PT and OT students have a significantly higher rate of hypermobility than the general population. [1-6] The presence of hypermobility is based upon the Beighton Hypermobility Scale. Given this information, PT and OT students may be at a higher risk for soft tissue injuries. With the highly physical nature of the professions, these individuals should be both conscientious of their hypermobility and proactive in protecting themselves from injury through the usage of proper body mechanics and protection of joints.

Research Question

1) What is the prevalence of hypermobility among PT and OT students? 2) Is there a higher incidence of soft tissue injuries in the PT and OT students who are hypermobile as compared to their non-hypermobile peers? 3) Is there a difference in hypermobility between men and women?

Hypotheses and Alternative Hypotheses

Null Hypothesis: 1) There is no correlation or causation between hypermobility and populations outside of PT, OT, and the general public. 2) There is no difference in the prevalence of hypermobility between PT and OT students in relation to the general public.

Alternative Hypothesis: A significant difference within PT and OT students is present for the prevalence of hypermobility. PT and OT students are more hypermobile than the general public.

Null Hypothesis: No significant relationship exists between the incidence rate of soft tissue injuries among PT and OT students who are hypermobile and those students who are not hypermobile.

Alternative Hypothesis: PT and OT students who are more hypermobile have a significant relationship to soft tissue injuries as compared to their peers who are not hypermobile.

CHAPTER II

LITERATURE REVIEW

When assessing joints in the body, some individuals have joints that move farther and more easily than others. There is a common belief that such individuals are "double-jointed"; however, this phenomenon is better known as ligamentous laxity in the joints. Joint laxity is characterized by increased length and elasticity of normal joint restraints resulting in an increased range of motion and increased distractibility.[8, 9] Excessive joint laxity, also known as hypermobility, has been associated with an increased incidence of musculoskeletal injuries including carpal tunnel syndrome, osteoporosis, chronic regional pain syndrome, and fibromyalgia.[2]

There are many terms for joint hypermobility including generalized joint hypermobility and its most commonly associated syndromes: joint hypermobility syndrome, Ehlers–Danlos syndrome, hypermobility type, Marfan syndrome, and osteogenesis imperfecta.[10, 11] Generalized joint hypermobility is defined as the finding of hyperextensibility in multiple joints with or without other accompanying chronic musculoskeletal complaints.[12] Joint Hypermobility Syndrome is "a connective tissue disease characterized by joint instability, chronic pain, and minor skin changes."[13] Ehlers-Danlos Syndrome's presentation is identical to joint hypermobility syndrome, and is defined as a connective tissue disorder characterized by soft hyperextensible skin and joint hypermobility. Hypermobility type is the most common and least severe form of Ehlers-Danlos Syndrome.[14,15] Marfan syndrome is an autosomal dominant inherited connective tissue disorder mostly caused by mutations in the structural component of

the extracellular matrix .[16] Osteogenesis imperfecta is a heritable connective tissue disorder involving deformities in the skeletal, neurologic, and cardiovascular systems.[10] Many of the systemic diseases are genetically inherited and can affect an individual's laxity.

The participants in this study were excluded if they had any previous disease of hypermobility. This study assessed joint laxity in the PT and OT students with healthy connective tissue. For the purpose of the study at hand, the term generalized joint hypermobility or systemic hypermobility will be used to refer to individuals who have a general hypermobility in their joints.

Prevalence

Hypermobility can appear in all joints of the body, and differs between individuals based on race, gender, and age. In one study, research showed that joint mobility decreases with age and that females have a higher rate of joint mobility.[17] Females may demonstrate higher degrees of hypermobility a result from having a different hormonal genetic makeup. Ten to twenty percent of individuals exhibit generalized joint hypermobility, particularly children, adolescents, females, and those of Asian and West African descent.[12] Another study reported that the prevalence of generalized joint laxity in children ages 6–15 years varies between 8.8% and 64.6%.[18] This range was large because there were many hypermobility variables that included physical activity, body mass index, and maternal education. The rate of joint hypermobility in the general public ranged from 4-13%.[19] These figures include individuals who did not have systemic disease.

Internal Factor Cause

The joint capsule, the surrounding ligaments, and tendons rely on the mechanical properties of the connective tissue matrix. This matrix is comprised of collagens, fibrilinis,

elastins, and proteoglycans. Type I collagen is the key structural composition of several tissues, and it is expressed in almost all connective tissues.[20] Mutations in the genes (COL1A1 and COL1A2) encoding type one collagen can cause joint hypermobility.[21] Another candidate gene for joint hypermobility could be in the mutations found in proteoglycans. Lumican and fibromodulin are two proteoglycans that regulate the assembly of collagen into higher-order fibrils in connective tissues. Deficiency in both of these proteoglycans could cause severe joint hyperlaxity. Tendons are bands of connective tissue which bridge the gap between a muscle and bone. Fibromodulin deficiency alone results in a significant reduction in tendon strength, while the tendon stiffness is further reduced with lumican deficiency.[22]

External Factor Cause

Generalized joint hypermobility could be a result of external factors such as sport participation. Competing in sports that require excessive amounts of tissue flexibility for an aesthetic appearance like dance or gymnastics can play a role in one's hypermobility. A recent study was done to assess the prevalence of hypermobility in a cohort of jazz dancers, and it concluded joint hypermobility was significantly more prevalent within the jazz dance group.[23] Another study evaluated the hypermobility in Brazilian students and teachers of ballet dance. The age of the volunteers ranged from 18-40, and it was required that subjects participated in at least five consecutive years of classical ballet practice. It concluded that teachers of ballet dance were three times more likely than the student to have joint hypermobility syndrome.[24] This could indicate that over time the repetitive force placed on the tissues caused the hypermobility. There is also a possibility that the volunteers were hypermobile before they began their many years of dance, due to the fact that their aesthetics of hypermobile joints made them good candidates for dance.

Implications

Hypermobility can be an asset to those who are involved in sports such as dance, gymnastics or baseball. However, studies have shown that hypermobility is associated with increased back and shoulder impairments. In one study, hypermobility syndrome was recognized more often in patients with spinal pain syndromes.[25] Another study showed that young males with joint hypermobility were found to have excessive lumbar segmental motion which was associated with increased low back pain and limited physical activity.[26] Dancers and gymnasts are able to put themselves in positions that the general public cannot, but these same positions may subject them to injuries later in life. Baseball pitchers may have excessive motion which is used to be able to pitch at high speeds but may experience pain and impingement as they age. A study showed that 61% of pitchers had a positive sulcus sign indicating greater inferior joint laxity at the shoulder.[27]

Measures

The Beighton scale was first developed in 1973 as an adaptation of the Carter Wilkinson scale. It was first used as a tool to identify hypermobility in Africa. [28] The Beighton score is used to measure generalized joint laxity and is still used today. The score is calculated by completing five maneuvers that can be done in one minute. The maneuvers include 1) hyperextension of the 5th metacarpal greater than ninety degrees, 2) hyperextension of the elbow greater than ten degrees, 3) hyperextension of the knee greater than ten degrees, 4) ability to bring thumb to forearm, 5) and the ability to touch palms to the floor. A Beighton score of four or more points out of nine is considered indicative of generalized joint hypermobility.[12] When used for goniometry, it is considered a reliable and valid instrument to measure generalized joint mobility in school aged children ages 6-12.[29] In one study, Beighton scores varied across the

lifespan and were significantly influenced by age, sex and ethnicity. Assessing generalized joint laxity using the Beighton scoring system required age and sex-specific cut-off scores based on the uppermost values.[30] There are other hypermobility scoring systems that have been devised, such as the Rotès-Quérol scale, Bulbena scale, Contompasis score, and the Lower Limb Assessment Scale. However, the Beighton scale was used in this study as it is the most common, most efficient, and the easiest scale to use. [31]

CHAPTER III

METHODS

Subjects

A total of 35 participants from the University of North Dakota volunteered to partake in this study, they ranged in age from 21 to 42. This research study was approved by the IRB, IRB-201904-258 (Appendix A). The subjects included in the study were currently enrolled in the physical therapy professional curriculum at the time of data polling. Participants were excluded if they were: pregnant, currently under the care of a physician for a musculoskeletal injury or had a known connective tissue disorder. One female participant was excluded due to being currently seen by a physician for a musculoskeletal injury. The final subject inclusion was n=34. Refer to Table 1 for the demographic particulars for the participants.

Instrumentation

Goniometric measurements for the elbow, 5th digit, and knee were taken with an EasyAngle® digital goniometer. The joints measured were determined based upon the Beighton Hypermobility Scale which includes the aforementioned along with passive apposition of the thumb to the forearm and forward trunk flexion (See Figures 1-5). Joints were documented in the format found in Appendix D. Intra-rater reliability was established prior to data collection to confirm goniometric consistency and reliability within the researchers. Reliability for clinical measurements is defined as at least .95. Following the completion of the reliability study, it was found that one researcher had a reliability of .949 for the elbow, a reliability of .948 for the knee, and a reliability of .983 for fifth digit extension. For the sake of the least possible measurement

error throughout the study, the same researcher collected goniometric measurements of all the participants.

Digital goniometers were found to have higher inter-rater ICC values, according to Carey et al.[32] They found that there was not a statistical significance between a digital goniometer and a universal goniometer. Given this information, a universal goniometer and an EasyAngle® digital goniometer were tested for reliability by both the researchers; however, the digital goniometer was chosen for this study based upon its greater reliability in a consistent manner as seen through the intra-rater reliability study.

Table 1. Demographics of participants

Characteristic	Mean	Range
Age (years)	23.8	21-42
Height(inches)	68.3	62-75
Weight (pounds)	163.9	115-265

Procedure

To initiate the study process, the participants read and signed the consent form (Appendix B). They were given insight into the intent and process of the study and were informed that they did not need to fill in any answers in which they wished to leave blank. Each volunteer was asked to fill out a paper report in addition to a Qualtrics online survey which both dealt with the participants injury history. The volunteers who met any or all of the exclusion criteria were thanked for their time and were informed that they could not participate in the study.

Once the participant had completed the survey, the researchers shifted to range of motion measurements by conducting the Beighton Hypermobility Assessment on each participant

(Table 2). The assessments were run in a private room in a standardized fashion to ensure patient confidentiality and authenticity of results. Each volunteer was filtered through a randomized order of fifth metacarpal extension, thumb apposition, elbow hyperextension, knee hyperextension, and forward trunk flexion measurements. Randomization was computed by an online randomizer generator. The researcher progressed from the participant's right to left side for each measurement. Ratings of hypermobility were given on a scale of zero to nine where a point was attributed to each joint measurement that was considered to be hypermobile (Appendix D). When subjects were measured and found to have four or more points in the "yes" column, they were classified as systemically hypermobile.[13]

The results of the Beighton Hypermobility Assessment were recorded on a data collection form marked by the participants identification number (Appendix D). In accordance with maintaining participant confidentiality, the identification number related to their survey was the only information linked back to the volunteer. Each joint measurement was recorded with an "X" in the column marked "yes" or "no" signifying hypermobility or lack thereof, respectively.

Data Analysis

All data collected from the surveys and injury history report included the volunteers age, gender, hand dominance, weight, and questions pertaining to inclusion criteria. These questions asked whether the participant was under active care of a physician for a musculoskeletal injury, was currently pregnant, unable to lie on their stomach, and whether they had any active connective tissue disorders. In addition, there were questions about current athletic/sports participation, current physical activity level, and any history of injury. If the volunteer had a history of injury, subsequent questions were asked regarding the mechanism of injury, whether

medical attention was sought, if PT or OT services were attained, if surgery was required, and if they had any lasting disability from the injury.

The data was collected and compiled utilizing IBM statistical descriptives. Due to the small sample size, only descriptives were used to define the sample. In addition, given the relatively limited sample size, this allowed the opportunity to look at individual joints with hypermobility even if there was a lack of systemic hypermobility. Subsequent analyses were run by hand to delineate if a relationship between hypermobility and type of injury could be ascertained.

Table 2. Beighton scale measurements

Measurement	Position	Directions	Goniometric Alignment	Point Obtained If
Fifth Metacarpal Extension	Seated with shoulder abducted, 90° elbow flexion and wrist in neutral	Subject asked to pull the proximal phalanx into extension to a degree that resulted in a stretch but did not elicit pain	**Axis**: 5th MCP joint **Stationary arm**: 5th metacarpal **Moveable arm**: 5th proximal phalanx	Subject had 90° or more of extension. One point per side (R/L)
Thumb Apposition	Seated	Examiner demonstrated and verbally described then the subject passively performed	N/A	Subject was able to oppose the thumb to forearm, one point per side (R/L)
Elbow Extension	Supine with shoulder 20° of abduction, neutral rotation, no flexion, and full wrist supination	Subject relaxed in supine with the olecranon resting on 2” half round foam roll	**Axis**: Lateral epicondyle **Stationary arm:** Acromion **Moveable arm:** Radial head citing the styloid process	Subject had 10° or more of hyperextension, one point per side (R/L)
Knee Extension	Supine with neutral hip rotation	Subject relaxed with heel on 10” bolster	**Axis:** Joint line **Stationary arm:** Lateral epicondyle and greater trochanter **Moveable Arm:** Fibular head and lateral malleolus	Subject had 10° or more of hyperextension, one point per side (R/L)
Trunk Flexion Test	Standing with feet shoulder width apart and knees extended	Examiner demonstrated and verbally described, then completed by subject	N/A	Subject was able to touch their palms flat on the floor

Figure 1. Measurement of the 5th digit extension records greater than 90°.

Figure 2. Apposition of the thumb to the forearm is exhibited.

Figure 3. Measurement of elbow hyperextension records greater than 10°.

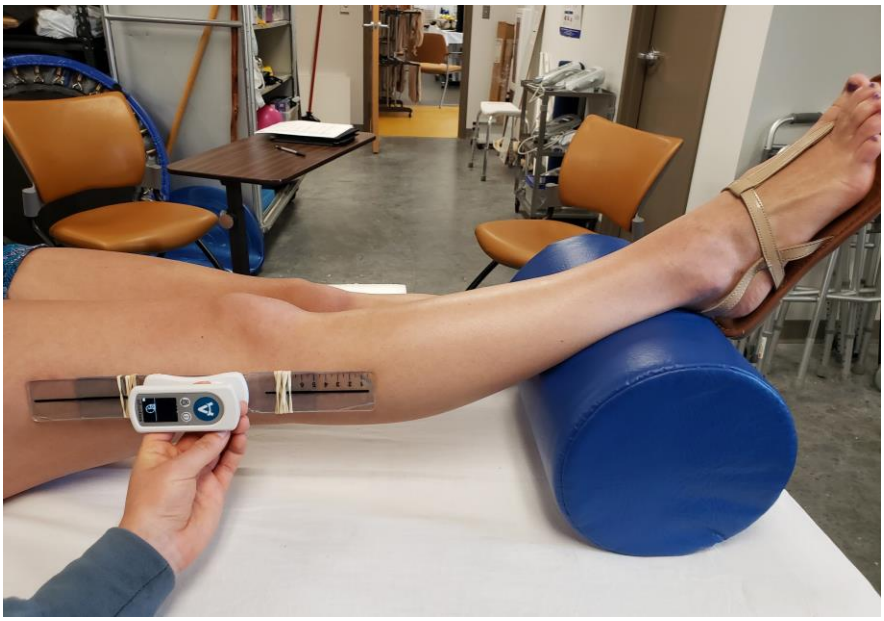

Figure 4. Measurement of knee hyperextension records greater than 10°.

Figure 5. Trunk flexion with palms placed flat on the floor is exhibited.

CHAPTER IV

RESULTS

Thirty-five PT students (13 male and 22 female) voluntarily participated in this research study. However, one participant was excluded leaving 34 subjects to be assessed and analyzed for hypermobility. In addition, there were not any OT student volunteers to allow for additional analysis between OT and PT students. It was found that 18% (n=6) of the overall subjects were systemically hypermobile. Systemic hypermobility is determined by a score of 4 or greater using the Beighton Hypermobility Scale. Of those that were classified as systemically hypermobile, there were five females and one male. The results of the assessments were categorized by location of injury and the percentage of sprains seen within people who have hypermobility. In addition, those without systemic hypermobility but who still presented with a hypermobile joint were looked at to assess whether injury may have been a factor in injury to that joint. (Table 2)

The electronic questionnaire indicated that the majority of the participants partook in athletic activity and physical activity on a weekly basis with a mean of 1.7 and 4.5 days a week, respectively. Of the 34 participants, all but one noted having had participated in at least one athletic activity in either pre-high school, high school, college, intramural, or non-organized athletics. The specific athletics that were most commonly participated in pre and during high school were basketball (average 19 subjects), volleyball (15), and track and field (14) (see Figure 6). However, the most prominent athletic activity partaken in during college was track and field (3 subjects), football (3), and baseball (3). For the general joint hypermobility participants, the

most common athletics were equally distributed in dance, track and field, volleyball, and cross country.

Table 3. Characteristics of the participants

Characteristics	n	Percentage
Gender		
Female	21	62
Male	13	37
Hypermobile		
Yes	6	18
No	28	82
Hand Dominance		
Left	3	9
Right	31	91
Joint Involvement		
Ankle	23	65.7
Knee	5	14.3
Fingers	7	20.0
Physical Activity (days/week)		
1	12	34.3
0	6	17.1
2	4	11.4

Reported data indicated that within the hypermobile and non-hypermobile populations; there was not a statistical significance regarding occurrence of sprain, strains/contusion, fracture, and dislocations (see Table 4). Data analysis was conducted on the number of participants that sustained a sprain prior to taking part in the study. A total of 26 participants, 76% of the subjects reported having sustained any form of sprain. Of those who had experienced a sprain, 58% were female. From the systemically hypermobile population, 66% reported having at least one sprain in any of the joints assessed. The joints which were assessed for occurrence of a sprain via a

questionnaire were as follows; toes, ankle, knee, hip, back/neck, shoulder, AC/SC joint, elbow, wrist, fingers, and thumb. The most commonly sprained joints were the ankle, fingers, and knee at 68%, 21%, and 15%, respectively (see Table 5). Of the people who were systemically hypermobile, the ankle and knee were the most common body locations that correlated with previous sprains (see Table 6). A total of 50% of the systemically hypermobile participants (3 out of 6) reported previous sprains in their ankle and 33% (2 out of 6) of these participants reported previous sprains of their knee.

In terms of areas of the body with the most hypermobility, the upper extremity exhibited the highest rates for all participants. There were a total of four participants where were considered systemically hypermobile based solely on having hypermobility in upper extremity joints. Throughout the entire upper extremity, the elbows and thumbs showed the highest rates of hypermobility. The right elbow was hypermobile in 44% of all of the participants while the left elicited 38% joint hypermobility. The right and left thumbs were hypermobile for 27% and 29%, respectively (see Table 7). The joint least likely to be hypermobile was the fifth finger, bilaterally.

Table 4. Injury type reported by participants

Type of Injury	**Systemically Hypermobile (N=6)**	**Non-Hypermobile (N=28)**
Sprain	67% (n=4)	79% (n=22)
Strain/Contusion	67% (n=4)	50% (n=14)
Fracture	50% (n=3)	45% (n=13)
Dislocation	0% (n=0)	7% (n=2)

Table 5. Areas with greatest risk for occupational injury

Joint Sprained	# Involved / 34 Participants	%	# of Females	# of Systemically Hypermobile with a	# of Systemically Hypermobile
Ankle	23/34	68%	13	3	2
Knee	5/34	15%	1	2	1
Back/Neck	2/34	6%	2	0	0
Shoulder	4/34	12%	1	0	0
Elbow	1/34	3%	0	0	0
Wrist	3/34	9%	2	0	0
Fingers	7/34	21%	4	0	0
Thumb	3/34	9%	2	0	0

Table 6. Systemically hypermobile people with sprains

Joint Sprained	# Involved / 34 Participants	%	# of Females	# Systemically Hypermobile with Sprain / Total # Sprained	% Systemically Hypermobile / Total Sprains	% Systemically Hypermobile / Total Participants
Ankle	23/34	68%	13	3/23	13%	9%
Knee	5/34	15%	1	2/5	40%	6%

Table 7. Hypermobility at each joint

Joint	**# Hypermobile**	**% of Participants**
Left 5th Finger	1	3%
Right 5th Finger	1	3%
Left Thumb	10	29%
Right Thumb	9	27%
Left Elbow	13	38%
Right Elbow	15	44%
Trunk	5	15%
Left Knee	2	6%
Right Knee	3	9%

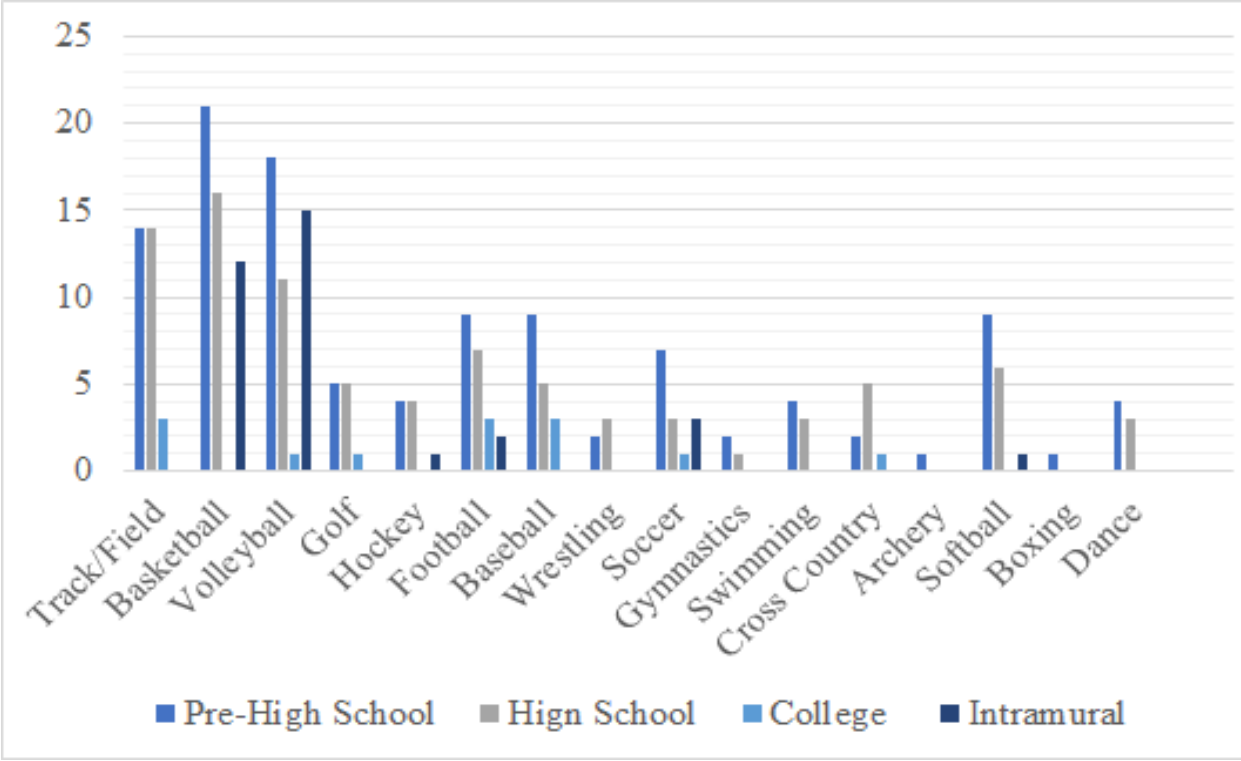

Figure 6. Portrayed is the number of participants that partook in athletics.

CHAPTER V

DISCUSSION AND CONCLUSION

Discussion

The results of the study showed that 18% of PT students exhibited systemic hypermobility with a total of 6/34 participants. Data could not be collected for a comparison with OT students as there was not a response from this subset of the population. The prevalence of joint hypermobility in PT students is greater than that of the general public which ranges from 4-13%.[26] Our findings support the assertions in literature that there is a higher rate of hypermobility in females than in males. This study found that of the six hypermobile students, five (83%) were female and one (17%) was male.

In previous studies and literature, it has been found that there is an increase in the number of musculoskeletal injuries when one is hypermobile.[2] This study did not support the literature as those who were systematically hypermobile reported less sprains and dislocations than their non-hypermobile counterparts; however, those with greater hypermobility did report a higher rate of strains/contusions and fractures but the difference was not statistically significant. For all subjects, sprains were most common and occurred most frequently in the ankles and fingers. This could be the result of the most commonly participated in athletics; basketball, volleyball, and track/field. In these sports, there is a large degree of twisting and rolling stress forces placed on the ligaments of the ankle during tactical movements (cutting, explosive start-stops, jumping, etc.) Similarly, sprains of the finger can be explained by an array of jamming, splaying, and/or bending of the fingers that can occur throughout a game/match.

The data collection process brought to light that a handful of participants had spent years in activities, dance and gymnastics. These sports demand a great deal of flexibility and even reward hyperextension. These repetitive end range motions very well may have impacted the hypermobility status of the subjects. Of the four dancers and two gymnasts, 50% of both types of athletes were systemically hypermobile. These findings partially confirm what research states about dancers having a higher prevalence of systemic hypermobility.[24] However, additional and expanded research is needed to determine if joint hypermobility varies by dance discipline and whether it is linked to genetics or habitual activities.

When breaking down which type of injury was most frequently involved and what joints had the highest incidence rates, it was found that sprains were most common in both populations. Within the 79% of non-hypermobile participants and 67% of the systemically hypermobile participants with a sprain, the ankle was most frequently reported. The ankle is not specifically assessed for hypermobility following the Beighton Hypermobility Scale; however, the Carter and Wilkinson criteria does include the ankle and looks for excessive dorsiflexion and eversion.[33] Given the high incidence of ankle sprains, including the ankle into the range of motion assessment may provide more data into the possible correlation of injury rate and hypermobility. The second most commonly sprained area was the fingers, yet none of these injuries occurred within the systemically hypermobile population. These sprains could, again, be attributed to the athletics that the participants partook in.

It was interesting to find that 62% of participants had one or more joints that were hypermobile regardless of whether or not they were systemically hypermobile. In addition, those that were systemically hypermobile ranged from zero to two days of weekly athletic activity which was on the lower side in comparison to the other participants. However, when looking at

weekly physical activity, the range increased to four to six days a week which averaged to be slightly higher (.44 days more) than their non-hypermobile peers. The results showed that 30% of the participants were hypermobile in their left thumb and 26% of the participants were hypermobile in their right thumb. This is concerning to physical therapy students who need to use their thumbs regularly for manual therapy as future joint problems could arise as a result of being hypermobile. Due to the higher incidence of systemic joint hypermobility in physical therapy students, it is imperative that these students are aware of their hypermobility status, the risk for associated injuries, and how to protect their bodies to sustain health and longevity in their PT careers.

In order to best reduce likelihood of injury secondary to hypermobile joints, preventative measures should be taken. Given that there is a tendency for people with generalized joint hypermobility to also have reduced proprioceptive acuity, it could be suggested that exercises be completed to combat this reduction. These exercises could encompass plyometric movements, single leg and table top exercises, and strengthening exercises. It is advised that excessive end range movements are avoided as continued stress into end range perpetuates the issue and increases the risk of injury.[13] In addition, preventative interventions such as taping can help to restrict the available range of motion and protect the joint in question. As always, utilization of proper body mechanics is always advised , whether one has generalized joint hypermobility or not.

Limitations of the Study

The study was limited by the number of participants partaking in the data collection and the inability to attain occupational therapy students. The intent of the study was to include both occupational and physical therapy students; however, only physical therapy students volunteered. Our results had a small sample size as a result of who was able to volunteer. Future studies would benefit from increased data collection time frames to allow for spring, summer, and fall students to participate. Another limitation of this study was possible participant misunderstanding of the electronic questions, inability to recall previous injuries, and overlooking some questions resulting in incomplete data sets. This posed a problem when looking at the relationships present for hypermobility and injury rates in the tested sample.

Improvements to this study could include a more detailed analysis of correlation between specific demographics of participants and correlation between specific sport involvement. In future studies, it is recommended that a larger sample size is utilized in addition to physical therapy students, occupational therapy students, and the general public to allow for greater data analysis. In addition, future studies could analyze the differences found between physical therapy and occupational therapy students. It would also be recommended that future studies look at the mechanism of injury and hypermobility status and the relationship between the two.

Conclusion

This research study investigated the prevalence of systemic hypermobility among PT and OT students. Due to a lack of OT student participation, it could only be shown that PT students have a higher prevalence of systemic hypermobility than the general public. This study concurred with prior research in that women are more prone to generalized joint hypermobility than their male counterparts. Those with generalized joint hypermobility were more likely to

have reported strains than those without hypermobility. In contrast, those without systemic hypermobility had greater rates of sprains and dislocations. Injury rates within the sample were high, with the most injuries coming from the ankles, fingers, and knees. This differs from the areas which indicated the highest rates of hypermobility, bilateral elbows and bilateral thumbs. The type of injury that was most prevalent was sprains, regardless of the participants' standing as having generalized joint hypermobility or not. Given that this study supported literature in PT students having a higher incidence rate of generalized joint hypermobility, it is imperative that these populations both be aware of their hypermobility status and take preventative actions.

APPENDIX A

UNIVERSITY OF NORTH DAKOTA

UND.edu

DIVISION OF RESEARCH & ECONOMIC DEVELOPMENT

Institutional Review Board
Tech Accelerator, Suite 2050
4201 James Ray Dr Stop 7134
Grand Forks, ND 58202-7134
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UND.irb@UND.edu

April 23, 2019

Principal Investigator:	Susan H.N. Jeno, PT, Ph.D.
Project Title:	Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury Among Physical and Occupational Therapy Students.
IRB Project Number:	IRB-201904-285
Project Review Level:	Expedited 4, 7
Date of IRB Approval:	04/16/2019
Expiration Date of This Approval:	04/15/2020
Consent Form Approval Date:	04/16/2019

The application form and all included documentation for the above-referenced project have been reviewed and approved via the procedures of the University of North Dakota Institutional Review Board.

Attached is your original consent form that has been stamped with the UND IRB approval and expiration dates. Please maintain this original on file. ***You must use this original, stamped consent form to make copies for participant enrollment. No other consent form should be used.*** It must be signed by each participant prior to initiation of any research procedures. In addition, each participant must be given a copy of the consent form.

Prior to implementation, submit any changes to or departures from the protocol or consent form to the IRB for approval. No changes to approved research may take place without prior IRB approval.

You have approval for this project through the above-listed expiration date. When this research is completed, please submit a termination form to the IRB. If the research will last longer than one year, an annual review and progress report must be submitted to the IRB prior to the submission deadline to ensure adequate time for IRB review.

The forms to assist you in filing your project termination, annual review and progress report, adverse event/unanticipated problem, protocol change, etc. may be accessed on the IRB website: http://und.edu/research/resources/human-subjects/

Sincerely,

Michelle L. Bowles, M.P.A., CIP
IRB Manager

MLB/sb
Enclosures

Cc: Chair, Physical Therapy

APPENDIX B

THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH

Project Title:	*Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury in Physical and Occupational Therapy Students*
Principal Investigator:	*Susan H N Jeno, PT, PhD*
Phone/Email Address:	*777-2831; susan.jeno@und.edu*
Department:	*Physical Therapy*

What should I know about this research?

- Someone will explain this research to you.
- Taking part in this research is voluntary. Whether you take part is up to you.
- If you don't take part, it won't be held against you.
- You can take part now and later drop out, and it won't be held against you
- If you don't understand, ask questions.
- Ask all the questions you want before you decide.

How long will I be in this research?

We expect that your taking part in this research will last _20 minutes____

Why is this research being done?

The purpose of this research is to determine if individuals identified with generalized joint hypermobility (excessive joint mobility) are at a higher risk of incurring musculoskeletal injury. The findings of this study will help determine if preventative steps need to be taken to prevent injury in individuals with hypermobility during the academic preparation and future professional practice. You will be made aware if you are identified as being hypermobile. Results of the study will be available to you to assess the need of a preventative program___.

What happens to me if I agree to take part in this research?

If you decide to take part in this research study, you will be asked to complete a questionnaire on the computer that will collect information about you, your activity level, and your injury history. You are free to skip any questions that you would prefer not to answer. The Beighton method of testing joint laxity and criteria will be used to as the measure of generalized joint hypermobility. You will be assessed on your ability to do the following tests: Hyperextend the little finger beyond 90 degrees, hyperextend the elbows beyond 10 degrees, hyperextend the knees beyond 10 degrees, touch the thumb to the flexor aspect of the forearm, and forward flex the trunk so the palms easily touch the floor with the knees fully extended. A scoring system of zero to nine is used with one point given for each extremity bilaterally and one point for the trunk if the test is positive for the stated criteria. If you score of 4 or more you will be considered hypermobile. It is expected that the entire procedure will take approximately 20 minutes to complete.

Approval Date: APR 15 2019
Expiration Date: APR 15 2020
University of North Dakota IRB

Date: _____
Subject Initials: _____

Could being in this research hurt me?

The most important risks or discomforts that you may expect from taking part in this research include is a momentary slight discomfort if you use excessive force to move your joint into position for the tests. You will be asked to move your joints only within your available range.

Will being in this research benefit me?
The most important benefits that you may expect from taking part in this research include learning whether you have generalized joint hypermobility and what you can do to protect yourself from injury if you are hypermobile.

Possible benefits to others include am expanded understanding of the hypermobility rates among Physical Therapy and Occupational Therapy students. This will help programs begin prevention programs during academic training.

How many people will participate in this research?
Approximately 200 people will take part in this study at the University of North Dakota.

Will it cost me money to take part in this research?
You will not have any costs for being in this research study.

Will I be paid for taking part in this research?
You will not be paid for being in this research study.

Who is funding this research?
The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

What happens to information collected for this research?
Your private information may be shared with individuals and organizations that conduct or watch over this research, including:

- The Institutional Review Board (IRB) that reviewed this research
- Only the researchers will have access to the information in this study.

We may publish the results of this research. However, we will keep your name and other identifying information confidential. We protect your information from disclosure to others to the extent required by law. We cannot promise complete secrecy.

Data or specimens collected in this research might be de-identified and used for future research or distributed to another investigator for future research without your consent.

Approval Date: APR 16 2019
Expiration Date: APR 15 2020
University of North Dakota IRB

Date: _____
Subject Initials: _____

What if I agree to be in the research and then change my mind?
If you decide to leave the study early, we ask that you let the researchers know your desire to leave the study. Your participation is voluntary. You may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. The investigators or you may stop the experiment at any time if you are experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to your health. If you agree to participate, you will be allowed to stop your participation in this study at any time without prejudice or jeopardizing any future relationships with the UND Department of Physical Therapy.

Who can answer my questions about this research?
If you have questions, concerns, or complaints, or think this research has hurt you or made you sick, talk to the research team at the phone number listed above on the first page.

This research is being overseen by an Institutional Review Board ("IRB"). An IRB is a group of people who perform independent review of research studies. You may talk to them at 701.777.4279 or UND.irb@UND.edu if:

- You have questions, concerns, or complaints that are not being answered by the research team.
- You are not getting answers from the research team.
- You cannot reach the research team.
- You want to talk to someone else about the research.
- You have questions about your rights as a research subject.
- You may also visit the UND IRB website for more information about being a research subject: http://und.edu/research/resources/human-subjects/research-participants.html

Your signature documents your consent to take part in this study. You will receive a copy of this form.

Subject's Name: _____

_____ _____
Signature of Subject Date

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

_____ _____
Signature of Person Who Obtained Consent Date

Approval Date: APR 15 2019
Expiration Date: APR 15 2020
University of North Dakota IRB

Date: _____
Subject Initials: _____

APPENDIX C

ID#_____

Patient Questionnaire

Name_____

Date of Birth_____ Height_____ Weight_____

Dominant Arm _ _ _ _ _ _ _ _ _

Sensitivity to: Latex Y N lsopropyl Alcohol skin sensitivity Y N
If yes, please explain
_____

Do you have any history of shoulder pain/pathology? Y N

If yes, please explain
_____

Do you have any history of back or spinal disc/pathology? Y N

If yes, please explain
_____

Are you pregnant? Y N

Do you have any condition for which lying on your stomach would be a problem? Y
N

If yes, please explain.
_____

All the information provided in this questionnaire has been answered accurately and to the best of my knowledge.

_____

Signature of participant Date

Place indicate your **age** at time of injury in the appropriate box to indicate the type of injury you have sustained, if more than one injury, please indicate the **number** (ie. 2 left ankle sprains age 16 and 18).

Sprain			**Strain/contusion**			**Fracture**			**Disclocation**		
Joint	Right	Left	**Muscle**	Right	Left	**Bone**	Right	Left	**Bone**	Right	Left
Toes			Foot			Toes			Toes		
Ankle			Anterior leg			Metatarsal			Metatarsal		
Knee			Posterior leg			Tarsal			Tarsal		
Hip			Quadriceps			Tibia			Tibia		
Back/Neck			Hamstrings			Fibula			Fibula		
Shoulder			Hip Adductors			Patella			Patella		
AC/SC			Hip Flexors			Femur			Femur		
Elbow			Gluteals			Pelvis			Pelvis		
Wrist			Low back			Vertebrae			Spine		
Fingers			Mid back			Rib			Rib		
Thumb			Neck			Clavicle			Clavicle		
Other			Abdominals			Scapula			Scapula		
			Anterior Chest			Humerus			Humerus		
Ligament Rupture			Biceps			Radius			Radius		
ACL			Triceps			Ulna			Ulna		
PCL			Wrist flexors			Carpal			Carpal		
MCL			Wrist extensors			Metacarpal			Metacarpal		
LCL			Finger flexors			Finger			Finger		
ATF			Other hand muscles			Thumb			Thumb		
Other			Thumb muscles			Skull			Skull		
						Jaw			Jaw		

Other (Please specify and include age you were when you were injured):

Of your listed injuries, please indicate **how many** injuries were due to:

Condition	**Sprain**	**Strain**	**Contusion**	**Fracture**	**Dislocation**	**Concussion**	**Other**
Overuse							
Trauma							
Other							

If known, please indicate what activity caused each injury listed above, choose 1 option for each injury.

Sport Performance							
Work							
General Activity							
Other							

Please indicate which, if any, injuries for which you sought medical attention.

Please indicate which, if any, juries for which you received Physical or Occupational Therapy.

Please indicate which, if any, injuries required surgery.

Please indicate which, if any, injuries resulted in lasting disability.

Thank you for your time with this research study.

APPENDIX D

ID #_____

DATA COLLECTION FORM

JOINT TESTED		YES	NO
5TH FINGER	LEFT		
	RIGHT		
THUMB	LEFT		
	RIGHT		
ELBOW	LEFT		
	RIGHT		
KNEE	LEFT		
	RIGHT		
TRUNK			
TOTAL SCORE			

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