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Identifying Ergonomic Risk in Marching Percussion

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Abstract: The "no pain, no gain" motto has long been followed when it comes to playing an instrument. Marching band members playing percussion instruments such as snare drums, tenor drums, and bass drums are subject to many repetitive movements and forceful exertions over long periods of time. The purpose of this study was to assess the ergonomic risks associated with marching percussionists through hand and body discomfort surveys, and traditional ergonomic assessment tools including the American Conference of Governmental Industrial Hygiene (ACGIH) Threshold Limit Value (TLV) for Hand Activity, Rapid Upper Limb Assessment (RULA), and Rapid Ergonomic Body Assessment (REBA).

Thirteen (13) male subjects of the Murray State marching band were recruited to participate in the study: six (6) snares, three (3) tenors, and four (4) bass players. Each subject was given a body discomfort survey during and after a marching band practice. Hand discomfort survey results indicated that the thenar eminence was the area of greatest hand discomfort and pain amongst the three types of drum players. Results from RULA and REBA analyses indicated that percussionists playing the three drum types were exposed to medium risk of developing musculoskeletal disorders. Whole body discomfort survey results revealed that snare and bass players experienced the highest discomfort and pain in the upper back; while tenor players experienced highest discomfort and pain in the lower back. Hand pain and discomfort results were also found to have a statistically significant effect on the scores calculated from ACGIH TLV for Hand Activity. Identifying the ergonomic risks associated with marching band percussion players would assist in bringing awareness of ergonomic principles to playing musical instruments.

Keywords: body discomfort survey, hand activity, percussion instruments

1. Introduction

Marching band percussionists are very susceptible to musculoskeletal disorders due to exposure to multiple stressors such as the posture of each player. Marching band evolved from being solely in the military to direct the movement of troops to college halftime shows during football games. Their role in the military was first used for soldiers to communicate with each other through long distances. There are many key components that still survive in marching bands today. Percussion in marching band is now used for consistent tempo and to add rhythmic flares to increase the complexity of music being played. The posture of each individual needs to be precise and consistent to deliver a sound performance. The earliest forms of ergonomics and musical instruments were studied by Ramazzini in his book *Disease of Workers*. Today over 50% of professional musicians reported having a musculoskeletal injury during their career (Heinan, 2008).

Musicians are usually not seen as athletes, but sustain injuries like any other sports players. Richard Norris (2007) explains in his book The Musicians Survival Manual that unlike runners and dancers who sustain injuries like stress fractures, musicians usually develop injuries like tendonitis that cause more chronic pain throughout their career. The ergonomic risks vary between instruments. For example, in string players, hand injuries are more common but in wind players elbow injuries were the highest among any section (Leaver, 2011). In another study, classical percussionists indicated the hands and lower back region as the highest prevalence of playing-related musculoskeletal disorders (PRMDs) (Sandell, 2009). Although there have been multiple studies on injuries in musicians, there is limited research on marching band players specifically. Many muscles are being used to play percussion instruments like snare drums, tenor drums, and bass drums. A study in 2006 hooked up a device that measured a percussionist's energy levels during a practice. Energy levels during marching band practice have been compared to the energy expenditure equivalent of running a 400-meter dash (Greenwald, 2010). Marching band members playing percussion instruments, such as snare drums, tenor drums, and bass drums, are subject to many repetitive movements and forceful exertions over long periods of time.

2. Method

2.1 Subjects

All subjects in the study play in the Murray State University marching band drumline. Thirteen (13) male subjects were recruited to participate in the study. Six (6) snare players, three (3) tenor players, and four (4) bass players participated in the study. There were six (6) freshmen, four (4) sophomores, two (2) juniors, and one (1) senior. All experimental procedures were approved by the Murray State University institutional review board (IRB).

2.2 Equipment

Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA), and ACGIH Threshold Limit Value (TLV) for Hand activity were used to evaluate ergonomic risks. Cornell body discomfort surveys were used to evaluate discomfort in the left hand, right hand, and whole body.

2.3 Procedure

The discomfort surveys were given one hour and thirty minutes into the three-hour marching band practice and directly following the marching band practice. RULA, REBA, and the ACGIH hand activity were measured during practice. RULA and REBA scores analyzed their average posture during practice while the ACGIH hand activity analyzed the maximum effort exerted in their hands to play the drum.

2.4 Statistical Analysis

All analyses were performed using Minitab 17. Multiple regression analyses were performed on the data collected using an alpha score of 0.05. A best-fit regression model was performed to determine if the drum type was a predictor of the RULA scores, the right hand discomfort of each subject was a predictor of the left hand discomfort, and the RULA score was a predictor of the whole body discomfort.

3. Results

The results of the hand discomfort survey are below in Table 1. Each area is split into right and left hand discomfort. Each number is the amount of subjects that indicated they had pain in that area. Table 2 has the results of the discomfort survey after practice. The highest level of discomfort in the right hand for snare players was in Area E, Area D, and Area C; the tenor drums Area D and Area E; and bass drum players marked Area A and Area B. Overall, Area E was marked the most throughout the drumline as being the location of pain and discomfort. The results between the two discomfort surveys were not significantly different.

Table 1. Hand discomfort during practice

	 Area A		 Area B		 Area C		 Area D		 Area E		 Area F	
Snare N=6	R 3	L 2	R 3	L 2	R 4	L 2	R 4	L 2	R 6	L 5	R 1	L 1
Tenor N=3	R 0	L 0	R 0	L 0	R 1	L 0	R 2	L 1	R 3	L 1	R 2	L 0
Bass N=4	R 3	L 3	R 3	L 3	R 1	L 1	R 1	L 1	R 2	L 3	R 1	L 1

Table 2. Hand Discomfort After Practice

	 Area A		 Area B		 Area C		 Area D		 Area E		 Area F	
Snare N=6	R 2	L 2	R 1	L 2	R 3	L 3	R 2	L 2	R 3	L 2	R 2	L 2
Tenor N=2	R 0	L 0	R 0	L 0	R 0	L 0	R 2	L 1	R 2	L 1	R 0	L 0
Bass N=3	R 2	L 2	R 2	L 2	R 1	L 1	R 1	L 1	R 1	L 1	R 1	L 1

To quantify the categorical data given in the survey, each marked area had three questions with a variety of answers. Each answer was given a numerical number and the answers for the three questions on each area were added together. This number was considered the total amount of pain in that specific area. The results of the whole body discomfort survey during and after a marching band practice are shown in Figure 1. The top three locations of the most significant pain, discomfort, and interference were the lower back, neck, and shoulders. The snare players experienced the most pain in the lower back. The tenor players experienced pain, discomfort, and interference of playing in the lower back area. The bass drum players had the highest ranking of pain in the neck.

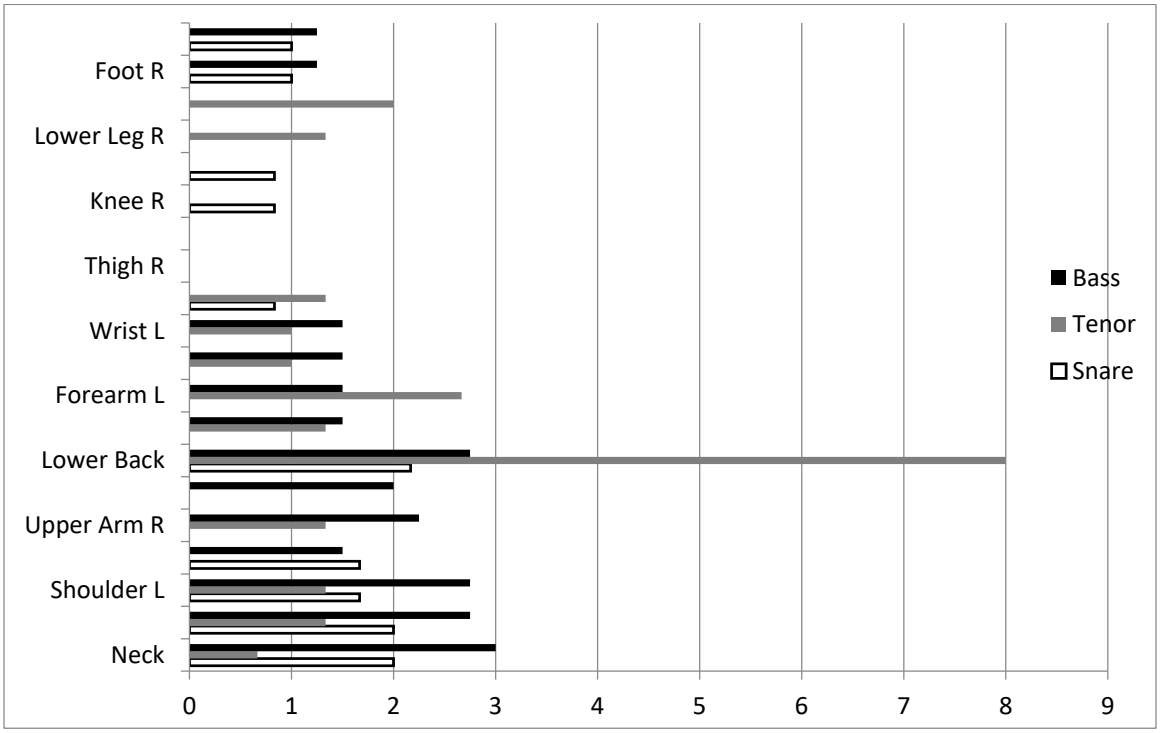

Figure 1. Average Discomfort During Practice

The results of RULA and REBA are below in Table 3 and 4. The average score on the RULA assessment was a 3.69. Out of the RULA scores, 46% of all subjects had a score of 3; 15.4% of the percussionists had a score of 4; and 38.4% had a score of 5. The snare player average RULA score was 4. The tenor section average score was a 4.33. The bass section average also fell into the same category with a score of 3.5.

Overall the REBA average score was 5.7. 77% of the subjects had a score between 4-7. 23% of the subjects have a score between 8-10. The average score of the snare section was 5.7. The average score of the tenor subjects was a 6.3. The average score of the bass section was a 5.75.

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Table 3. RULA scores

	1-2 (acceptable posture)	**3-4 (further investigation, change may be needed soon)**	**5-6 (further investigation, change soon)**	**7 (investigate and implement change)**
Snare N=6	0	4	2	0
Tenor N=3	0	1	2	0
Bass N=4	0	3	1	0

Table 4. REBA scores

	1 (negligible risk)	**2-3 (low risk) change may be needed**	**4-7 (medium risk) Investigate Change needed**	**8-10 (High Risk) Investigate Implement change**	**11+ (Very High Risk) Implement change**
Snare N=6	0	0	5	1	0
Tenor N=3	0	0	2	1	0
Bass N=4	0	0	3	1	0

The ACGIH TLV for Hand Activity states an action limit for the hand activity is 0.56 while the threshold limit value is 0.78. For the left hand ratio 7.6% of the subjects were below the action limit; 38.4% of the subjects have a score between the action limit and the threshold value limit (TLV); and 53.8% of the subjects had scores that were above the TLV. The average score of the left hand ratio was 0.97. The snare score average is a 1.0. The tenor score average is 0.645. The bass score average is a 0.87. All of the section averages are above the TLV. For the right hand ratio 7.6% of subjects were below the action limit; 30.7% of the subjects' scores fell between the action limit and the TLV; and 61.5% of the subjects scores were above the TLV. The right hand ratio for the tenor section increased to 0.98 from the left hand ratio. The bass section ratio average increased to 0.93 from the left hand ratio.

The RULA scores and the drum type did not have a significant difference in the regression model and therefore, the RULA score was neutral across the drumline ($p=0.492$). The results of the best-fit regression model indicated the right hand discomfort predicted the left hand discomfort ($p=0.004$). RULA was found to be the predictor of discomfort in the neck ($p=0.027$), upper back ($p=0.01$), and lower back ($p=0.032$).

4. Discussion and Conclusions

In the hand discomfort surveys, the drumline consistently experienced pain and discomfort in Area E. Area E is the location of the thenar eminence. Having pain in the thumb and the thenar eminence are possible symptoms of the development of carpal tunnel syndrome. For the tenor players, Area D was also a concern. This area of the hand contains lumbricals that can compress the median nerve. Since the compression is in the median nerve, this part of the hand can have pain and discomfort. Bass players felt pain in Areas A and B. These areas include all four digits of the hand. The thumb, index, and middle finger are usually where pain starts when developing carpal tunnel syndrome. With the amount of pain and discomfort in the hands being closely related to carpal tunnel syndrome, warm-up exercises may help prevent the development of CTS. One promising warm-up technique is a yoga routine. One study followed a group of subjects that were having symptoms of carpal tunnel syndrome participating in an eight-week yoga routine which increased the grip strength and eliminated most of the symptoms of each subject (Garfinkel, 2010).

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Whole body discomfort surveys indicated that the lower back had significantly more pain and discomfort than any other location. This may explain the importance and difficulty players have when positioning their harnesses and drum. All of the subjects used the same harness but their positioning of the drum was different. With bass drum players, the drum is positioned chest to waist while the snare and tenor drum players position theirs below the waist. Although the positions are different, this area had the same pain rating in each section. With that being said, each drum type is different. The weight distribution may be a contributing factor to lower back pain because the drum displaces the center of gravity away from the spine and increases the lever effect.

In each discomfort survey, the subjects did not indicate much interference with pain in their playing ability in the discomfort surveys. Even when subjects marked they had pain several times a day with substantial discomfort, they marked little to no interference while playing. This could be related to the environment where *pain* means *gain*. The Cornell body discomfort survey was of great assistance for studying the ergonomic risk factors because they were able to allow the researcher to pinpoint specific locations of pain and compare the discomforts between the three drums. Within each drum section, there was a variation of ergonomic risks from each other.

RULA and REBA scores for the subjects were compared with the study that assessed classical musicians in orchestras with RULA. The average score of our subjects was slightly higher than the wind players in the study that was a 3.6 (Kaufman-Cohen, 2011). All of the average scores in the different drum sections were below the RULA score found for string players in the study at 5.4 (Kaufman-Cohen, 2011). These scores do show that every subject in the study had a slight ergonomic impact meaning they could potentially develop discomfort or pain that could lead to a musculoskeletal disorder. These assessments were useful in this study, but the force/load was not measured for each percussionist. To measure the load/force there would need to be a way to measure the force absorbed in the hand from the subject hitting the drum with a drumstick. This would be significant area to further research to find a tool that would be able to measure this in drummers. One study tested this by using a force plate that was recorded by a DAT system (Dahl, 1997). This research might also lead to testing for hand-arm vibration syndrome. Depending on how much absorption is felt in the hand this could be another disorder that drummers could be at risk of developing.

The results of the ACGIH TLV hand activity show, the majority of the subjects were over the TLV when performing their music. The TLV is the limit a person can safely be exposed to a hazard. Marching band members are more prone to injury because they practice for several hours each day beyond the TLV. There have been studies that show the hand activity level assessment is a good indicator of the risk of carpal tunnel syndrome. One study found a dose–response relationship between biomechanical exposure and incidence of CTS (Bonfiglioli et al, 2013). Another study also indicated that associations were found between CTS and TLV for HAL when assessing this activity level indicating carpal tunnel (Kappellusch et al, 2014). This same study also found that subjects that were between the AL and TLV had the same risk for developing CTS as the subjects above the TLV. This assessment was very helpful at showing the risk of developing CTS in percussionists by giving an accurate range of activity.

The data collection methodology in this study was helpful in identifying the ergonomic risk factors of marching percussion. The discomfort surveys were helpful in locating the specific areas of discomfort for the different drum sections. The lower back, neck, and shoulders were of the most concern for the drum section as a whole. 77% of the subjects have pain in their lower back with 75% of the bass subjects, 100% of the tenor subjects, and 67% of the snare subjects indicating pain. In the hand discomfort surveys the most area of pain was Area E that contains the thenar eminence. Further investigation is needed to develop a plan to reduce discomfort associated in drumming. The ACGIH Hand Activity level was proven to be a significant tool in the study since the assessment is able to identify the risk for developing CTS.

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