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## PHYSIOLOGY & REHABILITATION | RESEARCH ARTICLE

# Upper extremity disability among string instrumentalists—use of the quick DASH and the NDI

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**Abstract:** *Purpose:* Playing the string instrument predisposes musicians to musculoskeletal problems in the upper extremity and trunk which usually affects more than one anatomical region. These musculoskeletal problems could result in difficulty in performing activities of daily living and playing a musical instrument. The aim of this study was to evaluate disability associated with musculoskeletal problems of string instrumentalists in South Africa by using the quick Disability of the Arms, Shoulder and Hands (DASH) and the Neck Disability Index (NDI) as measuring tools. *Materials and methods:* String instrumentalists from both amateur and professional orchestras were recruited via an electronic and a paper based survey to participate in the study by completing a self-administered questionnaire. The prevalence of musculoskeletal problems affecting performance was 56.6% and the trunk and shoulders were mainly affected. The overall disability scores of the QuickDASH and the NDI were  $12.9 \pm 13.2$  and  $11.5 \pm 9.8$  respectively. Symptomatic individuals had higher disability scores,  $13.9 \pm 13.8$  (QuickDASH) and  $15.0 \pm 10.5$  (NDI).

### ABOUT THE AUTHORS

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### PUBLIC INTEREST STATEMENT

Work related musculoskeletal disorder is a problem in several work populations. String instrumentalists are the most injured group among musicians and this study evaluated the limitations in activities of daily living associated with musculoskeletal problems in string instrumentalists. The demands of playing and performance which involves intensive repetitive shoulder movements and long practise hours resulted into activity limitation among the population studied. Shoulder movement is an important component of string playing and the pattern of movement is a risk factor for limitation in activities of daily living. This study emphasizes the need to evaluate the biomechanical components of shoulder movements involved in playing and proffer injury prevention strategies in order to prevent disability and improve performance.

**Conclusion:** The presence of musculoskeletal problems in one or more anatomic regions results in activity limitation and participation restriction of activities of daily living and it also impedes performance, therefore, it is important to evaluate the biomechanical structures involved in playing in order to proffer injury prevention strategies directly focussed on the basic components of performance.

**Subjects:** Allied Health; Physiotherapy; Rehabilitation Medicine

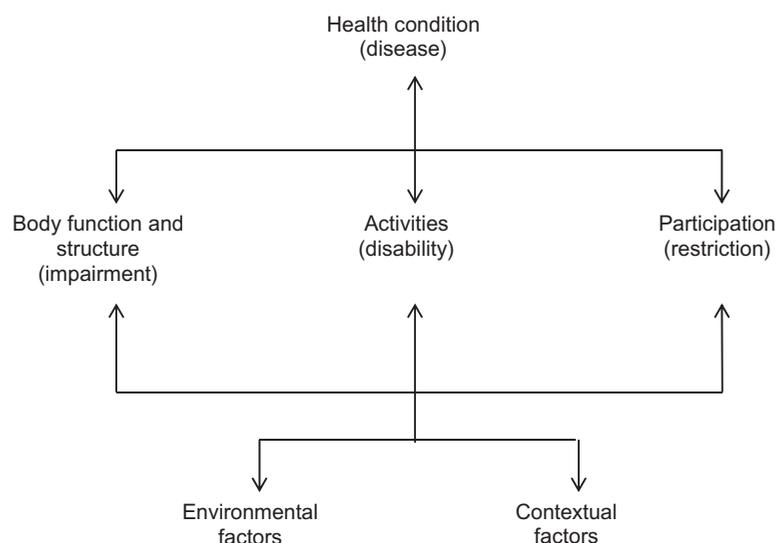
**Keywords:** disability; string instrumentalists; musculoskeletal; injury; musicians

### 1. Introduction

Disability associated with musculoskeletal problems is a burden in several work populations (Morse et al., 2007; Punnett et al., 2005). The extent of the problem has been reported as mild to severely disabling depending on the severity of the musculoskeletal problem (Fan, Smith, & Silverstein, 2008; Jester, Harth, & Germann, 2005; Luc, 2008). Musculoskeletal problem account for 37–77% of playing related health problems of instrumental musicians, especially in the trunk and upper extremities (Barnes et al., 2011; Paarup, Baelum, Holm, Manniche, & Wedderkopp, 2011; Zaza, 1998). String instrumentalists are the most affected of the instrument groups (Hagberg, Thiringer, & Brandström, 2005). In a typical orchestra, the bowed string instrumentalists are the largest instrument group and the prevalence of musculoskeletal injury is higher among bowed string instrumentalists when compared to other instrument groups (Kivimäki & Jokinen, 1994). Risk factors for musculoskeletal injury and disability include postural adaptation, repetition of movement (Moraes & Antunes, 2012) and socio-demographic factors such as age and gender (Davies & Mangion, 2002). Dysfunction of the musculoskeletal system especially muscles of the upper extremity and trunk due to playing the musical instrument is associated with pathology in the anatomical regions usually involved in playing the string instrument—trunk and upper extremity (Kaufman-Cohen & Ratzon, 2011; Leaver, Harris, & Palmer, 2011; Zaza, 1998). These pathologies have been shown to reduce function (Angst, Schwyzer, Aeschlimann, Simmen, & Goldhahn, 2011; Wu, Edgar, & Wood, 2007).

Disability is defined as “difficulty in doing activities in any domain of life due to a health or physical problem” (Verbrugge & Jette, 1994). The World Health Organization developed a model for the international classification of functioning and disability (ICF) (World Health Organization, 2005). The ICF model is an interaction of the disease as it affects the body structure, function, activities and participation, taking into consideration environmental and contextual factors as shown in Figure 1 (World Health Organization, 2005). The ICF model was adopted to evaluate the impact of playing related musculoskeletal disorders (PRMDs) (disease/injury) on body function (impairment), activities

**Figure 1.** ICF bio-psychosocial approach to functioning and disability.



(disability) and participation (restriction). Body structure impairment often results to activity limitation and participation restriction (Carreon, Glassman, Campbell, & Anderson, 2010; Nederhand & Hermens, 2003). Therefore, the null hypothesis that injury associated with playing the string instrument will not result into impairment and eventual limitation of activity and participation was used in this study.

Therefore, this study objectively measured disability among string instrumentalists in South Africa using the quick Disabilities of the Arm Shoulder and Hands (DASH) and the Neck disability Index (NDI). The study also explored disability associated with PRMDs among instrumental musicians as a baseline for future studies, such as evaluating the effectiveness of injury management programmes.

## 2. Materials and methods

A cross-sectional study using self-administered questionnaires to collect information on the prevalence, distribution and severity of musculoskeletal problems among string instrumentalists was conducted. The QuickDASH and the NDI were used to measure disability in the upper extremity and the neck respectively. Professional and amateur bowed string instrumentalists aged 18 and above, from 16 orchestras in South Africa, were invited to participate in this study. Ethical approval was obtained from the Human research ethics committee (Medical) at the University of the Witwatersrand (M130836). Informed consent was obtained for all the participants.

### 2.1. Instruments

Online survey and paper administered questionnaires were used to collect information on socio-demographics, musculoskeletal injury and disability outcome measures from the participants. The results of the prevalence and risk factors are the objective of a separate paper.

#### 2.1.1. Quick disability of the arm, shoulder and hand questionnaire (DASH)

The QuickDASH is an 11 item Likert self-reported questionnaire adapted from a 30 item questionnaire and it is used to measure physical function, ability to perform certain activities of daily living such as grooming, recreational activities, carrying objects and doing house chores and symptoms such as pain and discomfort in people with musculoskeletal disorders in the upper extremity and neck (Beaton, Wright, & Katz, 2005). It was adapted from a 30 item questionnaire and its reliability is high (95% CI 0.88–0.95) (Kitis, Celik, Aslan, & Zencir, 2009). The DASH score was calculated using the sum of the responses of the questionnaire (Institute for Work & Health, 2006). The DASH score ranges between 0 and 100, a score of zero (0) implies no disability while a score of 100 implies the most severe disability. According to earlier studies (Dixon, Johnston, & McQueen, 2008; Jester et al., 2005), the QuickDASH was classified into the three ICF domains. The QuickDASH has two additional sub-scores, the performing arts/sports and the work sub-score which include four optional questions on the impact of musculoskeletal injury in playing the musical instrument or sport and performing normal work routine at the optimal level respectively.

#### 2.1.2. Neck disability index (NDI)

The Neck Disability Index (NDI) that is a 10 item self-administered questionnaire, used to measure pain intensity, headaches and activities of daily living in people with neck problems (Vernon & Mior, 1991). The NDI has total maximum score of 50, the higher the score, the higher the disability (Vernon & Mior, 1991). It is a valid and reliable (95% CI (0.75–0.90)) instrument that is widely used to assess disability associated with neck problems (Pietrobon, Coeytaux, Carey, Richardson, & DeVellis, 2002; Vernon & Mior, 1991; Young et al., 2009).

#### 2.1.3. Sampling and sample size

A consecutive sampling technique was used to recruit participants. Sample size was estimated at 87 assuming the margin of error was 0.1 at 95% confidence interval and an estimated prevalence of 65% using the sample size formula to estimate prevalence in a survey ( $n = Z^2P(1-P)/e^2$ ) where  $n$  is sample size,  $P$  is estimated prevalence,  $e$  is margin of error and  $Z^2$  is the confidence interval.

**Table 1. Demographic characteristics of the participants**

Variable (N = 99)	Overall
Age (X ± SD) years	33.3 ± 15.3
Gender, n (%)	
Male	30 (30.3%)
Female	69 (69.7%)
String instrument, n (%)	
Violin	62 (63.3%)
Viola	14 (14.3%)
Cello	19 (19.4%)
Double bass	3 (3.1%)
Playing experience (X ± SD) years	22.8 ± 16.9
Practice hours/week (X ± SD) years	13.4 ± 11.8
Dominant arm, n (%)	
Right	87 (89.7%)
Left	4 (4.1%)
Both	6 (6.2%)

#### 2.1.4. Data analysis

The disability scores measured using the QuickDASH (Institute for Work & Health, 2006) and the NDI (Vernon & Mior, 1991) were calculated using the standard guideline. Descriptive statistics were used to summarise the frequencies and averages. Relationships between the dependent and independent variables was done by using the Pearson correlation analysis for linear associations and independent t-test was used to determine association between categorical variables and continuous variables assuming normal distribution. All analysis was done using the IBM SPSS statistics software version 22.0.

#### 2.1.5. Demographic profile of the participants

Twelve out of the 16 orchestras participated in this study with a total 99 respondents completing the disability outcome measure questionnaires. The average age and years of experience of the respondents was 33.3 ± 15.3 years and 23.1 ± 16.8 years respectively. The majority of the respondents were females 69 (70%) and played the violin 62 (63%) as shown in Table 1.

### 3. Results

Musculoskeletal problems were reported by 35 (35.7%) of the respondents (last seven days) and 56 (56.6%) reported symptoms of musculoskeletal problems over the last year.

Musculoskeletal problems were mainly reported in the low back (50.5%), upper back (49.5%), and neck (46.5%) and left shoulder (44.4%). Problems were reported in four or more body regions in the upper extremity and trunk by 39 (39.4%) of the string instrumentalists.

#### 3.1. Disability scores of the participants

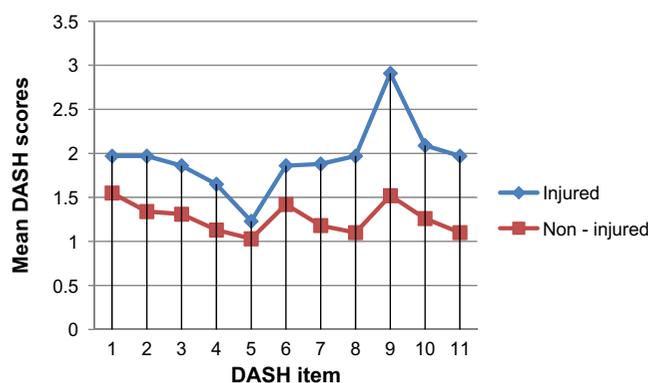
The QuickDASH and the NDI scores in the overall sample were 12.9 ± 13.2 and 11.5 ± 9.8 respectively. Independent t-test shows that disability outcome measure scores were significantly higher in the symptomatic respondents than in asymptomatic respondents as shown in Table 2 ( $p < 0.001$ ).

The specific question score of activities of daily living and symptoms showed that the mean activity DASH score of the injured string instrumentalists is highest in question 9 (Arm, shoulder or pain) and lowest in Question 5 (Use a knife to cut food), 2.91 and 1.65 respectively as shown in Figure 2. The result of the specific item score is reported in the supplementary material. The performing arts

**Table 2. Symptomatic and asymptomatic disability scores of string instrumentalists**

Disability outcome measure	Mean ± SD	p-value
QuickDASH	12.9 ± 13.2	0.00
Symptomatic	13.9 ± 13.8	
Asymptomatic	7.5 ± 7.7	
Activity limitation sub-score	11.4 ± 12.9	0.00
Participation sub-score	12.5 ± 17.8	
Impairment sub-score	16.3 ± 18.9	
Sports/performing arts (QuickDASH)	18.0 ± 20.5	0.00
Symptomatic	19.5 ± 21.3	
Asymptomatic	9.1 ± 12.4	
Neck disability index	11.5 ± 9.8	0.00
Symptomatic	15 ± 10.5	
Asymptomatic	8.0 ± 7.7	

**Figure 2. The graphical illustration of the mean DASH scores for each question item between the injured and non-injured string instrumentalists.**



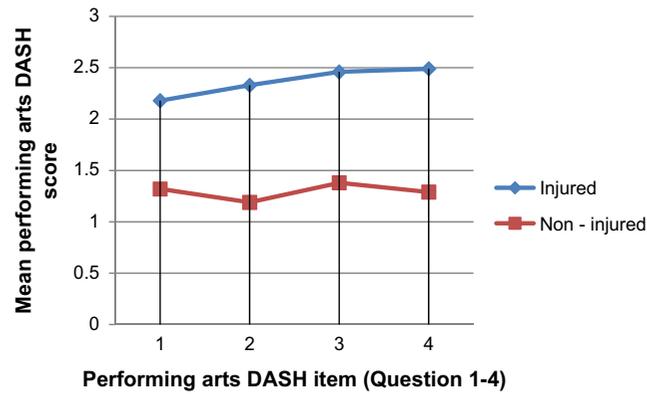
section of the DASH questionnaire showed the highest mean score in Question 4 (difficulty in spending your usual amount of time practising or playing your instrument or sport) and lowest in Question 1 (difficulty in using your usual technique for playing your instrument or sport), 2.49 and 2.18 respectively as shown in Figure 3. The NDI mean scores between the injured and the non-injured string instrumentalists was highest in question 5 (headaches) and lowest in question 2 (personal care), 1.7 and 0.23 respectively as shown in Figure 4.

**3.2. Association between disability scores and severity of musculoskeletal problems**

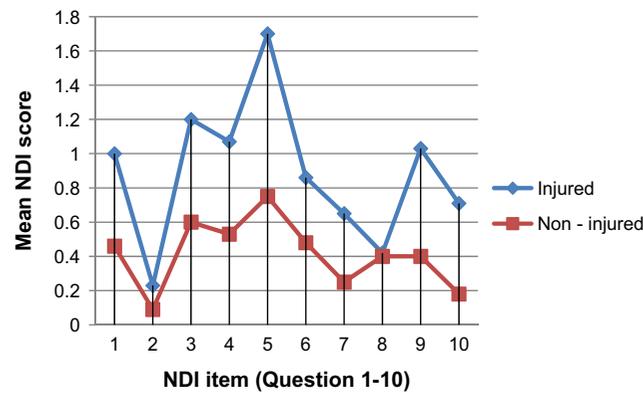
The Pearson correlation coefficient showed a weak positive correlation between the QuickDASH and the severity of musculoskeletal problems in the neck, upper back, right shoulder, left shoulder, right elbow, left elbow and the left hand as shown in Table 3,  $p < 0.05$ . The NDI also showed a significant positive moderate correlation with problems in the neck ( $r_p = 53$ ;  $p < 0.01$ ) and weak correlation with musculoskeletal problems in the upper back, right shoulder, right elbow, left elbow and left hand ( $p < 0.05$ ).

Linear regression analysis of the number of affected region and outcome measures showed a significant association with the general DASH scores and the performing arts DASH score OR (95% CI), 0.35 (2.50–0.73) and 0.35 (2.50–0.73),  $p < 0.001$  respectively. Multivariate analysis showed that the number of affected areas and practice hours significantly increases the disability scores for the general DASH scores and performing arts score as shown in Table 4.

**Figure 3.** The graphical illustration of the mean performing art DASH scores for each question item between the injured and non-injured string instrumentalists.



**Figure 4.** The graphical illustration of the mean NDI scores for each question item between the injured and non-injured string instrumentalists.



**Table 3. Association between disability and the severity of musculoskeletal problems in the anatomic regions**

	QuickDASH		NDI
	General $r_p$ (p-value)	Music $r_p$ (p-value)	$r_p$ (p-value)
Neck	0.39 (0.00)**	0.39 (0.00)**	0.53 (0.00)**
Upper back	0.35 (0.00)**	0.35 (0.00)**	0.32 (0.00)*
Low back	0.03 (0.75)	0.03 (0.75)	0.15 (0.19)
Right shoulder	0.39 (0.00)**	0.39 (0.00)**	0.35 (0.00)**
Left shoulder	0.45 (0.00)**	0.45 (0.00)**	0.19 (0.08)
Right elbow	0.33 (0.00)**	0.33 (0.00)**	0.34 (0.00)**
Left elbow	0.32 (0.00)**	0.32 (0.00)**	0.28 (0.01)*
Right hand	0.11 (0.28)	0.11 (0.28)	0.13 (0.25)
Left hand	0.34 (0.00)**	0.34 (0.00)**	0.27 (0.01)*

Note:  $r_p$  -Pearson correlation.

\* $p < 0.05$ .

\*\* $p < 0.01$ .

**Table 4. Univariate and multivariate association between outcome measures and independent variables**

	Univariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value
<i>DASH score</i>				
Age	0.02 (0.16–0.19)	0.85	0.18 (0.64–0.33)	0.52
Gender	0.14 (9.93–1.73)	0.17	0.12 (8.85–2.27)	0.24
Instrument	0.07 (4.25–8.80)	0.49	0.05 (4.38–7.54)	0.60
Practice hours	0.15 (0.40–0.06)	0.15	0.25 (0.48–0.05)	0.02*
Years of experience	0.03 (0.19–0.14)	0.75	0.28 (0.23–0.67)	0.33
Distribution of injury	0.35 (2.50–0.73)	0.00**	0.39 (2.55–0.83)	0.00**
<i>Performing arts score</i>				
Age	0.02 (0.16–0.19)	0.85	0.18 (0.64–0.33)	0.52
Gender	0.14 (9.93–1.73)	0.17	0.12 (8.85–2.27)	0.24
Instrument	0.07 (4.25–8.80)	0.49	0.05 (4.38–7.54)	0.60
Practice hours	0.15 (0.40–0.06)	0.15	0.25 (0.48–0.05)	0.02*
Years of experience	0.03 (0.19–0.14)	0.75	0.28 (0.23–0.67)	0.33
Distribution of injury	0.35 (2.50–0.73)	0.00**	0.39 (2.55–0.83)	0.00**
<i>NDI</i>				
Age	0.07 (0.10–0.19)	0.56	0.21 (0.19–0.42)	0.44
Gender	0.04 (5.31–3.84)	0.75	0.12 (1.61–5.83)	0.26
Instrument	0.01 (5.17–4.83)	0.95	0.02 (3.53–4.39)	0.83
Practice hours	0.12 (0.07–0.24)	0.28	0.08 (0.09–0.19)	0.46
Years of experience	0.07 (0.10–0.16)	0.64	0.07 (0.33–0.25)	0.79
Distribution of injury	0.42 (1.98–0.71)	0.00	0.51 (1.91–0.82)	0.00

\*p < 0.05.

\*\*p < 0.01.

#### 4. Discussion

The lifetime prevalence of musculoskeletal injury (56.6%) among string instrumentalists in our study is similar to earlier studies (7, 13). More females participated in this study than males, this is similar to other studies (de Greef, van Wijck, Reynders, Toussaint, & Hesselings, 2003; Mccrary, Halaki, Sorkin, & Ackermann, 2016). This study also emphasizes that PRMDs among string instrumentalists are associated with disability. The results of this study reported mild to moderate disability which is high enough to limit performance and affect activities of daily living. Musculoskeletal problems associated with playing a musical instrument usually affect more than one anatomic region (Bragge, Bialocerkowski, & McMeeken, 2006; Zaza, 1998). Similarly, in this study, a majority of the respondents reported problems in two or more anatomic regions, especially in the upper extremities and trunk. An increase in the number of anatomic region affected significantly increases disability scores. A higher disability score is associated with an increase in the severity of the musculoskeletal problem (Wong, Fung, Chu, & Chan, 2007).

The mean QuickDASH disability score was 12.9 in this study is comparable to an earlier study by Jester et al. (2005) that reported similar scores among general office workers with or without symptoms of musculoskeletal problems. A clinical diagnosis of musculoskeletal problems of upper extremity or neck dysfunction is associated with an increase in disability scores (Fan et al., 2008; Niekel, Lindenhovius, Watson, Vranceanu, & Ring, 2009). Our study found a marginal increase in disability scores in string instrumentalists with upper extremity musculoskeletal symptoms. The NDI has been used in several studies to measure disability associated with neck dysfunction in various clinical

settings (Kaale, Krakenes, Albrektsen, & Wester, 2005; Pool, Ostelo, Hoving, Bouter, & de Vet, 2007; Vernon, 1996). The NDI score in symptomatic string instrumentalists is lower when compared with other studies with patients' clinical diagnosis of neck pain attending an outpatient clinic for management (Cleland, Childs, & Whitman, 2008). A higher NDI score is often associated with the severity of musculoskeletal problems, a situation that can be explained by musculoskeletal problems of instrumental musicians included in this study are mainly mild to moderate which accounts for the lower NDI scores when compared with studies with clinical diagnosis of neck pain.

Specific activities of daily living affected by musculoskeletal injury are mainly with activities that requires heavy activities such as household chores and carrying bags. Also, activities that require rotation of the shoulder such as washing the back and opening a tight jar were affected. These are consistent symptoms of shoulder impingement syndrome (Neer, 1972, 1983). Shoulder pathology is a common musculoskeletal problem among string instrumentalists (Dale, Barrett, Halaki, & Driscoll, 2012; Moore, DeHaan, Ehrenberg, Gross, & Magembe, 2008; Pascarelli & Hsu, 2001). Playing the string instrument requires practise and it involves several combination of skilled joint movements in the upper extremity. Musculoskeletal problems reported in this study have shown to affect playing the string instrument and thereby affecting performance. Studies have shown that an increase in practise hours increases the risk of musculoskeletal injury (Kaufman-Cohen & Ratzon, 2011; Newmark & Lederman, 1987; Zetterberg, Backlund, Karlsson, Werner, & Olsson, 1998), which results in a limitation in activities of daily living and in playing the musical instrument. The repetitive movement and shoulder abduction which are normal movements involved in playing are known risk factors for the development of shoulder impingement syndromes (Cohen & Gerald, 1998; Frost & Andersen, 1999).

The mean neck disability score in symptomatic string instrumentalists in this study was 15.0 which is mild according to the classification by Vernon and Mior (1991). However, the score is higher than the normative values in the general population (Kato et al., 2012). In a comparable study, the mean neck disability score was slightly lower (NDI = 13.1) in patients with uncomplicated neck pain which after management was further reduced to 6.91 (Gay, Madson, & Cieslak, 2007). Musculoskeletal problems are associated with an increase in NDI scores which in this study is higher than in the normal population and even in patients with chronic neck pain (Kato et al., 2012). This suggests that in as much as the NDI score in this study among symptomatic individuals is mild, activity and participation is limited. Complications with neck pain such as radiculopathy, whiplash and spondylosis are often associated with higher disability scores (Fan et al., 2008; Nielke et al., 2009). Playing an upper string instrument requires intermittent lateral flexion of the neck to support and hold the instrument (Moraes & Antunes, 2012). It is logical that postural adaptation increases the likelihood of developing neck complications over time due to wear and tear and abnormal joint positions.

An increase in the number of anatomical regions affected, increases disability scores. This is not surprising as increase in dysfunction in more anatomic regions will increase activity and participation limitation and eventually disability (Keenan, Tennant, Fear, Emery, & Conaghan, 2006). Musculoskeletal problems of instrumental musicians usually affect more than one anatomical region due to the postural adaptation and repetitive nature required during performance. Repetition of movements predisposes the upper extremity to overuse injuries while stabilization of the instrument predisposes the trunk to back and neck problems (Wilke, Priebus, Biallas, & Froböse, 2011). Therefore it is important to explore injury prevention strategies in order to reduce disability associated with playing the musical instrument and other activities of daily living.

## 5. Conclusion and recommendation

The presence of musculoskeletal problems among string instrumentalists is associated with disability which impedes activities of daily living (ADL). This study has shown that the QuickDASH and NDI are useful instruments in measuring upper extremities and neck disability among string instrumentalists. A biomechanical analysis of the causative factors of upper extremity problems especially in

the shoulder with an approach to exploring injury prevention strategies could reduce musculoskeletal problems and eventual disability among string instrumentalists.

## 6. Limitations of study

Self-administered questionnaire studies rely on the subjective opinion of the respondent and it can be biased. The questionnaire was administered and completed by the orchestras at different music seasons of the year. Some completed the questionnaire at the peak of their season while some completed the questionnaire off-season, therefore, the data collected might not represent the overall prevalence of musculoskeletal problems among string instrumentalists in South Africa. Further studies should ensure that data collection procedure should factor in the schedule of the seasons.

## 7. Implications for rehabilitation

The prevalence of musculoskeletal problem among string instrumentalists is 56.6% and it affects mainly the upper extremity and the trunk.

Musculoskeletal problems of instrumental musicians usually affect more than one anatomical region and this result in an increase in limitation in activity, participation and function.

An understanding of the causative factors could be important in proffering preventive measures to reduce musculoskeletal problems associated with playing a string instrument and prevent eventual activity limitation and participation restriction as it pertains to activities of daily living.

### Supplementary material

Supplementary material for this article can be accessed here <http://dx.doi.org/10.1080/2331205X.2016.1234535>.

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### Competing Interests

The authors declare no competing interest.

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(DASH) and its short version (QuickDASH), shoulder pain and disability index (SPADI), American shoulder and elbow surgeons (ASES) society standardized shoulder assessment form, constant (Murley) score (CS), simple shoulder test (SST), oxford shoulder score (OSS), shoulder disability questionnaire (SDQ), and Western Ontario shoulder instability index (WOSI). *Arthritis Care & Research*, 63, S174–S188. <http://dx.doi.org/10.1002/acr.v63.11s>

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