Pain and Functional Limitation among rural female Gambian Head-Load Carriers a cross-sectional study

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Abstract

Background

Head-load carrying is a common phenomenon across sub-Saharan Africa. The Gambia shows an above average rate of female head-load carriers compared to other sub-Saharan African countries. Hitherto few studies have investigated the impact on women's' health due to head load carrying.

Objectives

The objective of this study was to determine whether head-load carrying characteristics, that includes besides others the carried weight; neck range of motion and proprioception could explain neck pain and functional limitation among female head-load carriers in rural Gambia.

Methods

Cross sectional study. Women aged 18 to 45 years with a minimum of one year of head-load carrying experience were examined. The relationship between explanatory variables such as upper cervical ROM and proprioception, and head-load carrying characteristics towards pain and functional limitation have been examined using regression models. Frequencies between functional limitation and regions of pain complaints have been determined.

Results

Neck pain complaints were most frequently reported. Functional limitation was stronger associated with lower back pain but not with neck pain. Limitations in upper cervical mobility was the strongest physical explanatory variable for pain and functional limitation. Women suffering from moderate to severe pain and functional limitation carried approximately three kg less weight.

Keywords: head-load carrying, neck, functional limitation, upper cervical spine

Introduction

Head-load carrying is a common phenomenon across sub-Saharan Africa. As gender roles are often defined, women and female children are expected to fetch water, collect firewood and do the house chores. Due to socio-economic factors and the absence of affordable transport possibilities, women and children carry heavy loads on their heads e.g. containers of water or bundles of firewood [1-3].

According to a recent review 88% of rural Gambian households have no direct water supply and 85% of water collection in these areas is achieved by women [1]. The Gambia shows an above average rate of female water collectors compared to other sub-Saharan African countries [1]. According to another review “much everyday transport work is achieved through head-loading” [2]. Petty trading is another common activity of women, selling their goods on plates and head carrying those most of the day [4].

From a health perspective, questions arise of how long-term head-load carrying affects the carrier’s health. A systematic literature review conducted on health impacts of women and children head-load carriers in sub-Saharan Africa concluded that research with a health perspective is very scarce [2]. Potential risks associated with women and children’s health are the load itself, including the weight but also its shape (fluid or solid), and the time or frequency of carrying [2, 3]. Musculoskeletal factors have been examined using imaging technology, leading to findings such as degenerative changes and spondylosis of the cervical spine [5-8]. A review by Belachew et al concluded that especially women develop degenerative disc disease in the upper cervical spine (UCS) [9].

Head-load carrying is assumed to require sensorimotor control, especially of the cervical spine [10, 11]. This involves proprioceptive input mainly provided by muscle spindles in the upper cervical spine, which helps to establish postural orientation and equilibrium [10, 11]. Sufficient neck mobility together with velocity and acceleration but also movement smoothness are regarded necessary to constantly adjust the head to the requirements of the task and within changing environmental conditions [12, 13].

In order to create appropriate health interventions, more health-focused studies on head-load carrying are needed. This study will address one small part of the complex of head-load carrying activity and will focus on the components of neck proprioception and range of motion (ROM).

Accordingly, the objective of this study was to determine whether head-load carrying characteristics, that includes besides others the carried weight; neck ROM and proprioception could explain neck pain and functional limitation among female head-load carriers in rural Gambia.

We hypothesized that ROM and proprioception of the cervical spine can partially explain pain and functional limitation related to head-load carrying in rural living Gambian women.

Material and methods

The nature of the study is exploratory. Data was gathered using a cross–sectional study design among rural female Gambian head-load carriers.

Recruitment and data were collected in a small village in the Gambia and within two working weeks (Nov/Dec. 2017). The study has been approved by the Gambian Government/MRC Joint Ethics committee (SCC 1554v1.1). The head of the village was informed about the project and spread the word to the women. The women who applied for participation were informed about the project and a consent document was given to sign or thumb print.

Inclusion criteria for participants were female; minimum one year of head-load carrying experience; age 18 to 45 years with or without any musculoskeletal complaints including unspecific cervical disorders; Mandinka, Wollof or English speaking; and living and working in the village.

Exclusion criteria were known fractures or tumours; diagnosed whiplash; known systemic inflammatory diseases like rheumatic arthritis; indications of fluorosis; and, to eliminate potential degenerative processes interfering with other variables, we also excluded women older than 45 years,

Assessments

Independent variables

Descriptive variables (age, body height and weight, number of children) and head-load carrying characteristics (weight, experience and frequency of carrying, time and distance of carrying, and additionally carrying a child) were recorded by self-report.

ROM measurements consisted of UCS flexion and extension and entire cervical spine, rotation left and right and lateroflexion left and right motions [14-16]. Proprioception tested as joint position error (JPE) of the entire cervical spine was measured in degrees by asking subjects to return to neutral head position after actively moving half range into flexion, extension, left and right rotation [11, 17, 18]. For all tests, three repetitions were executed by using the CROM device (www.spineproducts.com).

Dependent variables

Participating women were asked whether they perceive any functional limitation due to musculoskeletal complaints, especially neck pain. If yes, women were asked to name and rate affected activities by using the “patient specific functional scale” (PSFS) with zero meaning not able to perform the named activity and 10 meaning no functional limitation [19, 20]. Pain intensity was measured on a numeric rating scale with 0 meaning no pain to 10 meaning most severe pain (NRS) [21]. As most of the women were either illiterate or had only basic education, they had to be guided by the first author while rating the NRS and PSFS. Both subjective and objective measurements were carried out by two of the authors plus one assistant.

Sample size

A sample size calculation for a multiple regression model with an alpha of 0.05 and power of 80% had been conducted a priori. Different levels of $f^2 = \frac{R^2}{(1-R^2)}$ (the effect size) were used to calculate an appropriate sample size. Within that model R^2 represents the variance in the outcome variable (functional limitation or pain intensity) explained by the independent variables (ROM, proprioception and load carrying characteristics).

With an f^2 = 0.35 (medium effect size) and five explanatory variables a sample size of n = 42 had been determined [22].

Data processing

For ROM- and JPE-measures, mean values were calculated for further data analysis. For JPE the absolute, constant and variable errors were calculated [23]. Regarding the PSFS, two subgroups were created: Women who regarded themselves not functional limited (PSFS = 10) were compared with those functionally limited (PSFS 0-9). For pain intensity, also two subgroups were created: Women with no to mild pain intensity (NRS $\leq$ 4) were compared with those complaining of moderate to severe pain intensity (NRS $>$ 4) [24].

Data Analysis

A linear multiple regression analysis was conducted to assess how good independent variables could explain pain intensity or functional limitation. The number of explanatory variables had been reduced a priori; as they correlated strongly with other explanatory variables, e.g. amount of children correlated strongly with age, or the walking distance correlated with the walking time. A backwards regression method was used, with all explanatory variables forced into the model. Insignificant variables were eliminated stepwise from the model, until a best final model has been found. The adjusted R^2 value reflects how much variance of an outcome variable can be explained by a an optimal amount of explanatory variables. It is regarded as a less biased value for the best fitting model when

Variable	Mean	Standard deviation
Age in years	32.9	7.4
Body height (cm)	159.8	6.49
Body weight (kg)	60.9	10.85
Having Children (yes/ no)	35/ 4	NA
Number of children	3 (mode)	(1-8) (range)
Head-load carrying experience in years	18.6	8.3
Carried weight(kg)	28.08	4.67
Carried frequency (per day)	3 ((mode)	(1-7) (range)
Carried time (minutes)	29.7	23.4
Distance walked with load on head (meters)	851.3	503.1
Carrying additionally a child (yes/ no)	25/ 14	NA
Bodily complaints (yes/ no)	37/ 2	NA
Bodily pain on NRS (0-10)	5.05	3.0
Functionally limited in at least one activity (Yes/ No)	11/ 28	NA

compared to an unadjusted R^2. Statistical assumptions for linear multiple regression, including independence of error variance, linear relationships between explanatory and outcome variables, normal distribution of outcome variables for the set of explanatory variables, and homoscedasticity, described by the non-constant error variance were examined for each model [22, 25, 26]. In addition, independent t- tests for continuous data and odds ratios for count data (amount of painful regions) were executed to examine group differences of functional limited versus non-limited women, and between women suffering from no or mild pain versus those suffering from moderate or severe pain intensity respectively. All analysis was conducted by using Cran-R version 3.4.1 [27].

Results

From 42 female participants applied for examination, 39 could be included. Descriptive data is presented in Table 1. Three of the women applying for the study, did not fulfil the eligibility criteria and had to be excluded. While one woman was too old, another one suffered from rheumatic arthritis and the third one showed signs of fluorosis.

Table 1: Descriptive and head load carrying characteristics (n=39)

Variable	Mean	Standard deviation
Age in years	32.9	7.4
Body height (cm)	159.8	6.49
Body weight (kg)	60.9	10.85
Having Children (yes/ no)	35/ 4	NA
Number of children	3 (mode)	(1-8) (range)
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Bodily pain on NRS (0-10)	5.05	3.0
Functionally limited in at least one activity (Yes/ No)	11/ 28	NA

Caption Table 1: NA= not applicable

Thirty-five of 39 women complained about neck pain, followed by, in order of frequency, lower back pain (n= 14), headache (n= 8), chest-or thoracic pain (n= 8) and pain in the lower limbs (n= 2). Eleven women complained about a single painful region, twenty women named two regions, five women three regions and one-woman four painful regions. Two women had no pain at all. Sixteen women complained of neck and back pain, including upper and lower back, while seven women complained about neck pain and headache. One woman complained about neck and back pain, and headache.

Regarding functional limitation, eleven women claimed themselves impaired in at least one daily activity, three women named two impaired activities while one woman recalled three activities. Bending activities have been rated impaired by seven women, followed by doing the laundry (n= 3), ironing (n= 2) and lifting, cleaning and walking, each mentioned once.

Values for ROM of the upper and entire cervical spine and JPEs are presented in Table 2

Table 2: Cervical range of motion and proprioception in degrees (n= 39).

Variable	Mean	SD
ROM Flexion/Extension	74/61	8/11
ROM Lateral Flexion left/right	46/45	7/6
ROM Rotation left/right	67/67	9/9
Upper cervical Flexion/Extension	14/20	5/4
JPE Flexion/Extension		
Absolute error	6/8	3/6
Constant error	4/-7	5/7
Variable error	5/4	3/3
JPE Rotation left/right		
Absolute error	4/3	3/3
Constant error	-1/-1	4/4
Variable error	5/11	3/4

Caption Table 2: JPE= Joint position error, ROM= Range of motion, SD= Standard deviation

The final summary models of multiple linear backwards regression for pain intensity is illustrated in Table 3. Overall the model demonstrated an adjusted R^2 value of 0.25, which means that those independent variables that remained in the model can explain 25% of the variability for the dependent variable pain intensity.

Subgrouping the sample into women with no to mild pain (NRS ≤ 4) and moderate to severe pain (NRS >4) revealed, that women with no to mild pain (n=18) carried on average 3.05 kg more on their heads, compared to women with moderate to severe pain (n=21), (t= 2.93, p< 0.01). No other significant differences between pain groups in any other variable have been found.

Table 3: Final regression model to explain pain intensity

Coefficients	Estimate	SE	t-value	p-value
Intercept	19.05	5.8	3.28	< 0.01
Weight carried	-0.28	0.12	-2.33	0.03
Upper cervical extension	-0.28	0.14	-2.04	0.05
Upper cervical flexion	-0.09	0.09	-0.97	0.34
VE JPE flexion	0.33	0.14	2.37	0.02
Carry frequency (day)	0.46	0.29	1.60	0.12
Age	-0.08	0.06	-1.31	0.20

Caption Table 3: Residual standard error: 2.56 on 32 degrees of freedom. Adjusted R^2: 0.25; F-statistic: 3.11 on 6 and 32 DF, p-value: 0.016; VE JPE= Variable error for joint position error testing; SE= standard error of the estimate

The final summary models of multiple linear backwards regression for functional limitation is illustrated in Table 4. Overall the model demonstrated an adjusted R^2 value of 0.36, which means that those independent variables that remained in the model can explain 36% of the variability for the dependent variable functional limitation.

Subgrouping the sample into women with functional limitation (PSFS score < 10, n=11) vs. those without functional limitation (PSFS score =10, n=28) discovered that functionally limited women carried on average 2.7 kg less on their heads, when compared to women without functional limitation (t=2.09, p=0.05). Additional to that, women with functional limitation suffered more frequently from back pain (Odds ratio 4.99, 95% Confidence interval 0.94 to 31.2, p= 0.06).

Table 4: Final regression model to explain functional limitation

Coefficients	**Estimate**	**SE**	**t-value**	**p-value**
Intercept	1	6.17	0.16	0.87
Weight carried	0.40	0.12	3.37	< 0.01
Upper cervical extension	0.32	0.11	2.90	< 0.01
Cervical flexion	-0.12	0.05	-2.28	0.03
CE JPE extension	-0.09	0.07	-1.33	0.19
CE JPE flexion	-0.26	0.10	-2.71	0.01
CE JPE rotation left	-0.25	0.12	-2.10	0.05
CE JPE rotation right	0.24	0.12	2.03	0.05
Carry distance	-0.62	0.46	-1.35	0.19

Caption Table 4: Residual standard error: 2.32 on 30 degrees of freedom. Adjusted R^2: 0.36; F-statistic: 3.62 on 8 and 30 DF, p-value: 0.0047; CE JPE= constant error of joint position error testing; SE= Standard error of the estimate

Discussion

The major findings of the current study are that especially the weight carried, upper cervical spine flexion/extension ROM, and proprioception measured by the JPE could partially explain perceived pain and functional limitation. Women with moderate or severe pain and/ or functional limitation carry approximately 3 kg less weight on their heads.

Our study goes in line with other studies, which reported associations between the amount of weight carried and pain and/or stiffness in the neck and even early degenerations in the cervical spine in head-load carriers when compared to age-and gender matched non-carriers [4-8]. However, our findings that women suffering from moderate to severe pain carry less weight stands in contrast to those found in Limpopo Province in South Africa by Geere et al. [3]. These authors stated that on average subjects suffering from spinal pain carried 8.2 kg more, and while suffering from head or neck pain carried 4.6kg more weight compared to pain free subjects [3]. Geere et al.'s and our study differ in some aspects, as they also included male subjects and children of both gender, and additionally subjects older than 45years [3]. Furthermore they reported only water-carrying head-load subjects, usually performed by carrying large 20kg plastic containers, which has been regarded more difficult to transport due to its sloshing content within the container while walking compared to the same weight of lateral or anterior-posterior obtruding but stable firewood [2].

Early studies regarded the energy-saving effect of head-load carrying, as up to 20% of one's body weight can be carried without additional energy consumption compared to carrying the same weight on the back [28-30]. While no study so far has defined or recommend on a maximum weight which can safely be carried on the head without leading to spinal, neck or head complaints or early degeneration as shown in studies before [4, 6-8].

A weight reduction of approximately 3kg is regarded little compared to an average carried weight of 28kg and its beneficial effects might be questioned as women did still suffer from pain and/or functional limitations. However, a reduction of carried weights due to complaints might not always be possible or might be misjudged by subjects.

Limitations in upper cervical ROM and especially extension has been found important to explain pain and functional limitation in our study. Upper cervical mobility seems to be more important for head-load carrying compared to mobility of the entire cervical spine as continuing adjustments balancing the weight may better be achieved by small and fast movements around a movement axis closer to the carried weight in the UCS. Limitations in UCS mobility have been frequently reported in patients suffering from headache in association to their neck pain [15, 31, 32]. Flexion/extension ROM restrictions have not been reported that often, with Rudolfsson et al. reported UCS extension more limited in neck pain patients compared to control subjects, while Ernst et al. demonstrated stronger correlations between impaired UCS flexion to reported headache [15, 31]. As nearly all women in this sample complained about neck pain and eight of 39 about additional headache, restrictions in the UCS ROM irrespective of the direction might not be regarded unexpected.

Neck and back pain are somehow established conditions in rural African populations [4, 33, 34] with head-load carriers demonstrating even more early degenerative findings in the neck [4, 5]. Compared to prevalence values from rural Ethiopia by El-Sayed et al. our sample demonstrated much larger prevalence values of both neck and back pain [33]. Although more women complained about neck pain, back pain was stronger associated with functional limitations while additional neck pain did not further increase this association. In general, less than one-third of the women regarded themselves functional impaired, with most of the impairments were related to typical lower back activities such as bending movements during lifting, doing the laundry and cleaning. None of the women stated that the head-load carrying activity itself has been limited, although those reported to be functional limited carried less weight on their head.

We assumed that head-load carrying needs fine-tuned sensorimotor control of the neck, with optimal neck proprioception as one prerequisite. We therefor decided to examine the joint position error in our subjects. Our statistical analysis though demonstrated some contrary results to explain functional limitation. Especially the variable errors for rotation left and right differ widely which might be, at least partially, explained in a lack of understanding the nature of the tests in many women. Measuring JPE by using the CROM device has been done in studies before [35, 36], while other studies typically used laser pointers mounted on the head and a target to project the laser beam [37]. The latter kind of method has been dismissed during the planning of the study as to complex, but in the aftermath might be regarded better for our sample to become familiar with the aim and nature of the test itself, while receiving feedback from a laser beam on a target. Due to this inconsistency in JPE measurements, we regard conclusion derived from proprioceptive results as limited.

Further limitations of the study were that many participants had difficulties in understanding the NRS and PSFS scales. Scales with facial expressions might make ratings easier for the participants to comprehend. Furthermore data sampling has been done cross-sectional, impeding predictive ability of explanatory variables or even cause-effect relationships [38]. With explanatory variables explaining “only” 25% of pain intensity and 36% of functional limitation, other variables should be regarded to explain variability in outcome variables. Considering the current sample, performance tests for the lower back might be considered

[39]. While neck pain conditions might need additional testing to examine motor and other psychosocial functions [40-42].

To conclude, rural Gambian women, who regularly carry weights on their heads, suffer frequently from neck and back pain. Back pain is more frequently found in women with functional limitations. Increased pain intensity and functional limitation has been found to be related to a reduced amount of weight carried on their heads and to more restrictions in upper cervical spine mobility. Associations to proprioceptive deficits of the neck should not be inferred from our study.

Declarations of interest

The authors report no conflict of interest

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Acknowledgements

We would like to thank Marco Hiestand, and the Saho family for their tremendous support throughout the process of this research study. Demba Faye for helping during the measurements. Samba Bah for helping in the organisation. The Alkalo and all the participants of Marakissa Village, The Gambia.

Authors' contributions

MHS outlined the study, collected the data and drafted the manuscript, PS outlined the study, obtained the ethical approval and proofread the manuscript, MJE outlined the study, helped collecting the data, analysed the data and proofread the manuscript.

All authors read and approved the final manuscript.

Disclosure statement

The authors declare no conflict of interest

Funding details

No funding has been received

Data availability statement

The datasets generated during and/or analysed during the current study are not publicly available due but are available from the corresponding author on reasonable request