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Trunk postural demands of occupational activities of some merchant pregnant women in Benin, West Africa

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Strenuous physical work puts expectant mothers at risk of experiencing back pain during the gestational months. Pregnant women in Benin perform physically demanding occupational tasks that include the lifting and carriage of heavy loads on their heads for commercial activities. A large percentage of pregnant subjects (58%) reported having back pain episodes since the start of their pregnancy. However, the mean Oswestry score of the affected participants was relatively low with a mean score of 0.2 (SD: 0.12), on a scale form 0 to 1. An evaluation of the postural demands of the occupational activities of these women revealed that they performed on average 328 trunk flexions at angles exceeding 60°, with 66 of these flexions sustained for more than 4 s, during the average 7.9 h where trunk postures were recorded. They also spent on average 36% of the recording time at trunk flexion angles larger than 20°. These results show that the merchant pregnant women in the Porto-Novo area in Benin are at great risk for developing back disorders during pregnancy.

Practitioner Summary: Results will make a first contribution to the literature by identifying the stressful postures adopted during a typical day. The findings of this study can help in the development of preventative concepts and postural modification techniques to decrease the occurrence of back pain during pregnancy for women in Benin.

Keywords: Africa; occupational activities; trunk posture; inclinometer; back pain; pregnancy

1. Introduction

Back pain during pregnancy is such a frequent problem that it is sometimes looked upon as a part of normal pregnancy for women across the world (Nagi *et al.* 1973, Reisbord and Greenland 1985, Fast *et al.* 1987, Wu *et al.* 2004, Bastiaanssen *et al.* 2005). Back pain can be severe enough in some cases to limit the pregnant women in their ability to work and perform daily activities (Ostgaard *et al.* 1991). Although back pain during pregnancy is common, its causes still remain unclear. However, several biological, social, biomechanical and occupational factors have been found to contribute to the problem (Cheng *et al.* 2009). Of these factors, strenuous physical work, such as frequent lifting and sustained postures were identified to be associated with increased risk of developing low back pain during pregnancy (Cherry 1987, Heliovaara 1989, Rungee 1993). Similarly, Endresen (1995) reported that twisting or bending several times an hour during the workday were the occupational factors associated with the greatest risk for pelvic and/or lower back pain. Although these studies mainly focused on pregnant women in industry, these risk factors are also likely valid for women in other parts of the world who perform physically demanding work outside an industrial setting. More specifically, women in West Africa participate in laborious daily occupational activities. Those daily duties include a variety of tasks ranging from farm work, drawing water from wells and carrying the water to errands around the house, such as doing laundry, washing dishes and sweeping the floor. West African women also frequently take part in commercial activities that require the carriage of heavy loads on their heads for long periods of time with repetitive bending and lifting motions.

These physical tasks and sustained trunk postures expose West African women to a great risk of musculoskeletal disorders, especially back pain. However, the characteristics of their daily occupational and head load carriage tasks are not well documented in the literature. Furthermore, to the author's best knowledge, no posture analysis on this specific population has been performed to define the trunk postures assumed at various points throughout the day.

Consequently, the objectives of this investigation were to (1) identify the principal daily occupational tasks performed by pregnant merchant women in Porto-Novo, Benin, West Africa; (2) gain descriptive information

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on the specific task of head load carriage; (3) describe bodily pain associated with this specific task and (4) measure trunk postures of pregnant women during their occupational activities in a field setting in Benin. This descriptive information on the daily occupational tasks and postures assumed by these pregnant women will allow a better understanding of the physical demands of this understudied population. The first three objectives were attained using questionnaires, a subjective method, while the objective measurements were used for the fourth objective.

2. Methods

2.1. Participants

Twenty-six pregnant women (age 26.6 $\pm$ 5.3 years) and a control group of 25 non-pregnant women (age 26.4 $\pm$ 7.5 years) with past or present experience of head load carriage were recruited in Porto-Novo, Benin, to participate in this study. Inclusion criteria for this study required that women be able to carry a load corresponding to approximately 20% of their body weight. Pregnant subjects were recruited at a community maternity centre, while non-pregnant subjects were recruited through local contacts to match the pregnant women sample in age and height. Mean height and weight for the non-pregnant women were 158.8 cm ($\pm$6.0) and 56.0 kg ($\pm$10.6), respectively, while the mean height and weight for the pregnant subjects were 158.8 cm ($\pm$6.0) and 63.0 kg ($\pm$14.74), respectively. Due to problems in locating all the pregnant subjects at their residences, only 17 (age 26.1 $\pm$ 5.4 years, height 157.6 $\pm$ 5.5 cm, weight 63.5 $\pm$ 11.69 kg) of the initial 26 pregnant women participated in the second part of the study where trunk postures were measured throughout the day. The study protocol was approved by the Queen's University Research Ethics Board and by the Institut National de la Jeunesse, de l'Éducation Physique et du Sport (INJEPS) Ethics Board in Porto-Novo, Benin. Informed consent was obtained from all subjects.

2.2. Instrumentation

2.2.1. Questionnaires

Three questionnaires were used in this study. The first questionnaire was designed to obtain information about the demographics and daily occupational tasks of our subject population. A section on head load carriage was also included in this questionnaire to gain descriptive knowledge of this specific task. The second questionnaire was a modified version of the Oswestry 2.0 questionnaire (Fairbanks and Pynsent 2000) where the original questions were adapted to the lifestyle of women in West Africa. The purpose of the Oswestry Low Back Pain Disability Questionnaire is to assess pain-related disability in individuals with low back pain. In this study, it was used to rate the severity of back pain experienced in the six months prior to the start of the study for non-pregnant women or since the start of pregnancy for pregnant subjects. The Oswestry disability index (ODI) was computed as suggested by Fairbanks and Pynsent (2000) from the answers to the 10 questions in the questionnaire. The scores range between 0.0 and 1.0, and indicate the degree of functional limitations due to low back pain. The last questionnaire was a pain drawing (Sturesson *et al.* 1997) where all subjects identified the body parts where they experienced pain during the specific task of head load carriage. More than one area could be pointed out. These locations were coded as neck and shoulders, upper back, lower back, pelvis, buttocks, thigh, calf, foot, front pelvis and pubic region. A visual analogue scale (VAS) was used to indicate the level of bodily pain where a value of 0 corresponded to slight discomfort and 10 to severe pain.

2.2.2. Trunk posture

Trunk postural data during a typical day for women in Benin were collected using a Virtual Corset^{TM} (VC) (MicroStrain, Williston, VT, USA). This device is an inclinometer system combined to a miniature datalogger enclosed in a light pager-sized plastic case. It is battery-powered, wireless and composed of two bi-axial accelerometers positioned orthogonally. Using an algorithm developed by the manufacturer, the accelerations measured by the accelerometers are transformed into angle data to monitor trunk inclination with respect to the line of gravity or with respect to a subject's upright position in two directions (flexion and lateral bending). The data were sampled at a rate of 7.5 Hz and stored on the built-in non-volatile memory of the device until the end of data collection at which point the data were downloaded to a computer via the Windows-based Virtual Corset control software (VC-323; Microstrain Inc.) for further analysis.

2.3. Procedure

2.3.1. Questionnaires

As part of a companion study (Beaucage-Gauvreau *et al.* 2011) on head load carriage, 26 pregnant and 25 non-pregnant subjects were invited to come to the INJEPS. At the beginning of the visit, all participants were asked to answer two of the three questionnaires; the demographic questionnaire and the Oswestry 2.0. The subjects then lifted and carried loads on their heads for a distance of 6 m as part of the other study. The mean weights of the loads carried by the participants were 11.33 kg ($\pm$2.12) and 11.75 kg ($\pm$2.24) for the non-pregnant and pregnant subjects, respectively, and corresponded to approximately 20% of their body weight. Typical loads were mocked by a bag of sand and placed on a circular metal tray, which was in turn placed on a small stool for the lifting and lowering phases of the head load carrying task. These lifting and head load carriage conditions were observed in the field and replicated in the laboratory. Immediately after completing this task, the subjects were asked to identify the areas where they experienced bodily pain during head load carriage on the pain drawing and to indicate the severity of the pain using the visual scale. Due to the illiteracy of most of our subjects, the questionnaires were translated from French to the local dialect, read aloud and the answers were transcribed by a student from the INJEPS.

2.3.2. Trunk posture

Participants were instrumented with a VC at the level of C7 at the beginning of the day to obtain the inclination angles of the upper trunk with respect to the subject's upright neutral posture in two directions: flexion-extension and lateral bending. The VC was placed as close as possible to the bony landmark of C7 on the back of the subject in a custom pocket secured to the trunk using elastic Velcro straps around the torso and shoulders (Figure 1). The bony landmark for C7 was determined by palpation while subjects flexed their necks. The VC was also aligned with the body anatomical axis. Prior to launching the VC, participants were asked to stand in their most upright standing

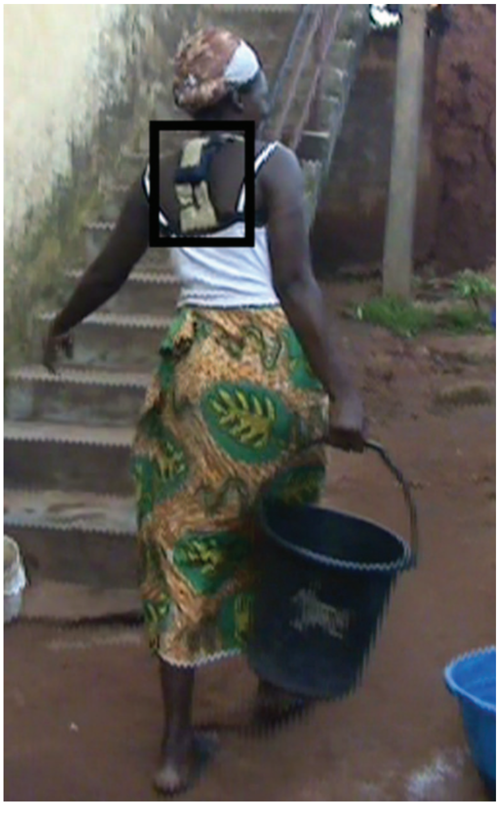

Figure 1. Pregnant women instrumented with one VC at the level of C7. The VC is enclosed in the navy blue pocket to minimise its displacement (shown in black box). Tape was also used over the adjustable feature of the harness to secure it to the women's torso.

trunk posture to set the reference position of the VC. Subjects were instructed to carry out their normal activities and ignore the presence of the VC on their back for the whole day. The investigators then returned to the subjects' residences several hours after the start of data collection to remove the instrument.

2.4. Trunk data processing

All data were processed using custom software developed in Matlab R2007B (The Math Works Inc., Nathick, MA, USA).

First, all lateral bending angles above 70° on either side were manually removed from the stream of angle data as this maximum limit was stated by the manufacturer for the instrument. Angles larger than this limit were also believed to occur for postures where the subjects were lying on their sides to rest, and thus irrelevant for our study on postures throughout the day when performing occupational tasks. All the corresponding flexion-extension angles were also deleted as the data were considered to be skewed. Furthermore, once the lateral bending angles exceeded 70°, cross-talk occurred with the flexion-extension angles rendering them invalid for analysis.

The trunk flexion and lateral bending angles were analysed separately. An analysis was performed for the trunk flexion angles based on the guidelines of the rapid upper limb assessment (RULA) (McAtamney and Corlett 1993); the percentage of time spent at 0° (neutral position), between 0° and 20°, between 20° and 60°, and above 60° was calculated. The underlying idea in these angle classifications is that joint position is most favourable when it is near its neutral position. Trunk extension was also analysed and separated into two categories: percentage of time spent in trunk extension smaller than 10° and trunk extension larger than 10°. For side bending, the percentage of time spent at 0° (neutral position), angles between 0° and 20°, and above 20° on both sides was determined based on an article by Freitag *et al.* (2007).

The number of trunk flexion occurrences in excess of 60° throughout the day was also determined counting each bending motions. The numbers of these sagittal bends lasting longer than 4 s were also counted as they are thought to represent static postures (Freitag *et al.* 2007).

3. Results

3.1. Questionnaires

3.1.1. Demographic information

The demographic information for the subject population of this study is summarised in Table 1. Most subjects were self-employed, which in this case corresponded to commercial activities. Approximately half of each of the two subject groups, non-pregnant and pregnant, had a low monthly income under 15,000 XFO which converts to approximately US$29. The mean stage of pregnancy for the pregnant women was 24.9 ± 9.5 weeks; however, there

Table 1. Demographic information on the subject population of this study obtained by the demographic questionnaire.

Demographics	Non-pregnant	Pregnant
Mean age (years)	26	26
Mean gravidity	2.6	2.3
Education level*		
No education	56% (14)	54% (14)
Elementary school	32% (8)	31% (8)
Middle school	12% (3)	8% (2)
Employment		
Stay at home	–	31% (8)
Self-employed	100% (25)	69% (18)
Employee	–	–
Income* ($\times$1000 XFO)		
<15	52% (13)	50% (13)
15–30	32% (8)	35% (9)
30–50	4% (1)	4% (1)
>50	12% (3)	8% (2)

Note: *These questions were not answered by all subjects.

was a large variation between the different stages of pregnancy of the subjects with weeks into the pregnancy ranging from 10 to 36 weeks.

Answers to the questions about the head load carriage task included in the demographic questionnaire are summarised in Table 2 with the reported weight of the loads shown in Table 3. The weights of the loads included in Table 3 were not measured objectively using a scale, but are rather a reported value based on the questionnaires filled by the subjects. Figure 2 illustrates different types of loads carried by women on their head. The team lifting method, which is typically employed for heavier loads, consists of two people lifting the load simultaneously on opposite sides of the tray that holds the load and placing it on one of the lifters' head. Vendor's types can be classified in two categories: walking and fixed merchants. Walking merchants refer to women who carry their merchandise on their head all day stopping only to make a sale, while fixed merchants only carry their goods on their heads to and from their sale stand at the start and end of the day. The latter type of merchant occupies the same location throughout the day.

3.1.2. Daily activities

The 10 activities most frequently reported in the questionnaires by the two groups along with their mean duration and weekly occurrence are listed in Table 4. Highly flexed stoop trunk postures and sustained trunk postures were

Table 2. Descriptive information on head load carriage obtained from the subjects of this study.

Questions	Non-pregnant	Pregnant
Variation of duration of head load carriage throughout the week*		
Yes	56% (14)	38% (10)
No	44% (11)	58% (15)
Mean day-to-day variation (min)	195 ($\pm$144)	151 ($\pm$122)
Head load carriage more difficult during pregnancy*		
Yes	N/A	65% (17)
No	N/A	27% (7)
Lifting of the load more difficult during pregnancy*		
Yes	N/A	73% (19)
No	N/A	19% (5)
Lowering of the load more difficult during pregnancy*		
Yes	N/A	85% (22)
No	N/A	8% (2)
Cause of increased difficulty for pregnant women		
Enlargement of abdomen	N/A	50% (13)
Back pain	N/A	8% (2)
Others	N/A	23% (6)
Method to lift load when non-pregnant*		
Alone	52% (13)	54% (14)
Team of 2	48% (12)	42% (11)
Method to lift load during pregnancy*		
Alone	N/A	31% (8)
Team of 2	N/A	62% (16)
Type of merchant*		
Walking	56% (14)	73% (19)
Fixed	44% (11)	23% (6)
Variation of weight of load throughout week		
Yes	88% (22)	77% (20)
No	12% (3)	19% (5)
Number of voluntary stops to rest*		
<5	100% (25)	88% (23)
6–10	–	4% (1)
>10	–	–
Number of voluntary stops to rest during pregnancy*		
<5	N/A	65% (17)
6–10	N/A	15% (4)
>10	N/A	–

Note: *These questions were not answered by all subjects.

observed for activities, such as doing dishes, doing laundry (both performed at ground level) and cleaning/sweeping (performed using a short-handled broom) (Figure 3). All pregnant women noted that they had more difficulty completing these tasks during pregnancy.

3.1.3. Oswestry disability index

Fifty-eight percent of pregnant women reported experiencing back pain since the start of their pregnancy while only 36% of the non-pregnant subject group suffered from back pain in the last six months. However, the mean Oswestry score of the affected participants was very similar between the two groups: 0.19 ± 0.11 for the non-pregnant women and 0.20 ± 0.12 for the pregnant women on a scale from 0 to 1. These ODI scores for the two subject groups were not significantly different ($p = 0.05$) when compared using a *t*-test.

Table 3. Weight of the load carried on the head by the subjects, as reported in the questionnaires.

Subject group	Weight of load (kg) 0–5	5.1–10	10.1–15	15.1–20	>20
Non-pregnant	4% (1)	24% (6)	36% (9)	12% (3)	24% (6)
Pregnant*	8% (2)	12% (3)	27% (7)	31% (8)	19% (5)

Note: *Question was not completed by all subjects.

Figure 2. (A) Woman carrying vegetables and fruits; (B) woman carrying mattresses; (C) woman carrying toothpaste; (D) women carrying varying products such as coal, nuts and vegetables.

Table 4. Top 10 occupational activities enumerated by the subjects of this study.

	Number of subjects		Mean occurrence (weekly)		Estimated mean time to complete task (min)	
Daily activities	Non-pregnant	Pregnant	Non-pregnant	Pregnant	Non-pregnant	Pregnant
Cooking	25 (100%)	25 (96%)	11	11	104 (±49)	85 (±65)
Doing dishes	22 (88%)	24 (92%)	13	12	12 (±7)	14 (±13)
Going to market	24 (96%)	24 (92%)	3	5	109 (±92)	97 (±59)
Cleaning in the house	22 (88%)	23 (88%)	9	9	51 (±66)	32 (±37)
Grinding condiments	19 (76%)	23 (88%)	3	4	23 (±31)	12 (±10)
Going to get water	23 (92%)	20 (77%)	14	14	19 (±29)	17 (±24)
Making bed/spreading out mattress	25 (100%)	24 (92%)	8	7	4 (±4)	3 (±2)
Doing laundry	25 (100%)	25 (96%)	5	3	93 (±74)	127 (±109)
Cleaning around the house	12 (48%)	10 (38%)	9	12	8 (±7)	21 (±32)
Going to get wood	–	2 (8%)	–	3	–	13 (±4)

3.1.4. *Pain drawing*

The body areas identified as painful during head load carriage by the two subject groups are shown in Table 5.

3.2. *Trunk postures*

Trunk postures were recorded on 17 pregnant subjects for an average of 7.9 h (±2.0 h). The mean percentage of the duration of data collection spent in certain postures outlined by RULA is shown in Table 6. An average of 328 (±247) trunk flexion events (flexion angles of 60° or more) were recorded during the day with 66 (±54) of them lasting longer than 4 s. The mean lasting time of the all flexion angles larger than 20° was 5.8 (±2.7) s, while the mean lasting time for flexion at angles larger than 60° was 5.1 (±3.1) s. For lateral bending, a small average percentage of time (8%) was spent at angles larger than 20°. Rather, the majority of time was spent in postures

Figure 3. (A) Woman doing the dishes; (B) woman drawing water from the well; (C) woman doing laundry; (D) woman sweeping the floor with a short-handled broom; (E) woman cooking using coal; (F) women grinding condiments.

Table 5. Body areas where subjects experienced pain along with their mean VAS score on a scale from 0 to 10.

Body areas	Non-pregnant		Pregnant	
	Percentage of subjects with pain	Mean VAS score	Percentage of subjects with pain	Mean VAS score
Neck and shoulders	12% (3)	2	16% (4)	3
Upper back	4% (1)	1	12% (3)	4
Lower back	8% (2)	5	4% (1)	2
Pelvis	24% (6)	6	42% (11)	4
Front pelvis	–	–	15% (4)	5
Pubic region	–	–	8% (2)	3
Buttocks	–	–	4% (1)	4

Table 6. Percentage of time spent in different trunk flexion postures outlined by RULA and in trunk extension.

Subject no.	Percentage of time spent in trunk flexion-extension positions					
	Flexion >60°	Flexion 20°–60°	Flexion 0°–20°	0°–neutral position	Extension 0°–10°	Extension >10°
1	3	54	35	4	4	0
2	7	35	43	6	7	1
3	6	33	28	7	23	2
4	13	18	40	6	15	8
5	0	12	50	5	12	22
6	3	17	45	10	22	2
7	13	29	48	5	5	0
8	3	29	48	7	11	2
9	3	17	43	10	25	2
10	9	29	42	7	12	1
11	5	52	41	2	1	0
12	3	32	52	5	9	1
13	15	19	24	8	26	8
14	9	30	53	3	4	1
15	3	54	41	2	1	0
16	2	19	57	10	12	0
17	7	34	30	8	19	2
Average	6 (±4)	30 (±13)	42 (±9)	6 (±3)	12 (±8)	3 (±5)

within the range of 0°–20° (56% in left lateral bend and 28% in right lateral bend), with only 9% in the neutral position.

4. Discussion

The objective of this study was to gain knowledge of the head load carriage task and different daily occupational tasks of merchant pregnant West African women, as well as to perform an analysis on the postural demands of their occupational activities during a typical day to assess the risk of back pain problems during gestational months. The results showed that these pregnant women were at a high risk of developing back pain during pregnancy because of the heavy loads lifted for head load carriage, as well as the large number of trunk flexions above 60° and the sustained flexed postures throughout the day.

4.1. Back pain in African women

The incidence rate of back pain among pregnant women in this study, 58%, agrees with previous studies that reported prevalence rates in the range of 48–56% (Mantle *et al.* 1977, Fast *et al.* 1987, Ostgaard *et al.* 1991). Furthermore, the low mean Oswestry scores show that most of the subjects experienced only mild back pain at worst, similarly to what was found by To and Wong (2003) and Wu *et al.* (2004). Approximately 85% of the sample had no schooling or only the completion of elementary school. This lack of formal education typically leaves these women with few options to gain a salary. Consequently, most of them go on to become self-employed merchants who carry various heavy loads on their heads. In line with this presumption, all of the non-pregnant subjects and a large majority of pregnant women (69%) were self-employed street vendors. This profession, although physically demanding, is not rewarded by high wages as shown by the low monthly earnings of less than 30,000 XFO monthly (approximately US$58) in 85% of the participants. People in lower socioeconomic classes and with low education have been shown to experience more lower back pain than those in upper socioeconomic class (Nagi *et al.* 1973, Carey *et al.* 1995, Toroptsova *et al.* 1995).

4.2. Head load carriage and related bodily pain

Lifting or carrying heavy loads have also been shown to increase intra-abdominal pressure and possibly stimulate early contractions (Hayne 1981). Furthermore, loads are lifted farther from the spine during pregnancy due to the presence of the enlarged abdomen in the front; this increased lever arm during lifting then creates additional stress on the pelvic muscles and ligaments (Tapp 2001). Due to ligament laxity in the pelvis region, spine joints become less stable, which in turn increases the risk of back injury (Tapp 2001). The American Medical Women's Association (1993) suggested a maximum load of 10–12 kg for pregnant women. Nearly 80% of the expectant mothers in this study exceeded the maximum recommended loads, thus exposing themselves to the possible adverse consequences of heavy lifting during pregnancy. It is also suggested that pregnant women seek help when lifting loads to reduce the demand on the back muscles.

The low occurrence of lower back pain in pregnant women in the pain drawing could be explained by the certain level of misclassification and confusion suggested in the literature when localising pain in the lower back and posterior pelvic regions (Albert *et al.* 2000, Wu *et al.* 2004). In addition, a certain level of difficulty in the communication with the subjects could have influenced the precise area identified as painful by the subjects. As such, this miscommunication represents a limitation of this study that could have altered the results. A larger percentage of women showed signs of pain in the posterior pelvic region in both subject groups with nearly half of the pregnant women (42%) reporting experiencing pain at this location during the lifting, carrying and/or lowering of the load on their heads compared to 24% in the non-pregnant group. Furthermore, only the pregnant group identified the front pelvis and pubic region as a source of pain. The discomfort reported in the pelvis region is probably caused by the increased biomechanical strain on ligaments, muscles and skeleton during pregnancy.

In a study performed by Lloyd *et al.* (2010), the neck was identified as the body area where the most pain and discomfort was felt by the subjects during head loading. Subjects in the study by Lloyd *et al.* (2010) used a VAS and interviews to indicate the areas of the body associated with pain and discomfort. The results of this study agree with these findings, with both subject groups reporting the neck as a body area associated with pain.

4.3. Daily occupational activities

Sagittal trunk inclinations exceeding 20° are regarded as significant in increasing the risk of developing musculoskeletal injuries by several postural assessment tools (McAtamney and Corlett 1993, Hignett and McAtamney 2000) and have been identified as a risk factor for the development of low back disorders in industries (Marras *et al.* 1993). Recordings of trunk postures of 17 pregnant women revealed that the pregnant women spent an average of 36% of the time period when data were collected bending forward at angles larger than 20°, corresponding to an average of 2.8 h for the mean 7.9 h where trunk posture were recorded. Doing the laundry, doing the dishes, cooking, making the bed/rolling the sleeping mat and cleaning inside and outside the house (sweeping) are six of the top 10 activities (Table 2) that all are performed in trunk postures well in excess of 20° of flexion. The lower back extensor muscles must work harder during trunk flexion to counteract the increased mechanical moment created by the weight of the upper body (Keyserling 2000). These exertions result in high compressive forces on the spinal motion segments (Keyserling 2000). On the other hand, the risk posed by awkward postures from lateral bending was relatively low with only 8% of the total measurement time spent outside the safe range of 20° of lateral bend (Freitag *et al.* 2007).

An average of 328 inclination events greater than 60° were recorded for the monitoring duration corresponding to 41.5 inclinations per hour. This high number of trunk flexions shows that the movements of women in Benin are highly repetitive throughout the day. Repetitive bending motion below the knee level more than 10 times per hour are recommended by the ACOG (2002) to be stopped at 20 weeks of pregnancy. Repetitive motion is another risk factor for low back pain as it results in cumulative loading of the spine (Norman *et al.* 1998). Studies on cadavers have shown that cyclical loading reduces the mechanical tolerance limits of the lumbar spine, indicating a greater risk of failure due to fatigue (Brinckmann *et al.* 1987, Hansson *et al.* 1987, Callaghan and McGill 2001).

The duration of trunk flexion outside the neutral range is an additional factor that must be included in the evaluation of postures. Risk of injury from static postures with unsupported trunk inclination is believed to be caused by muscle fatigue that leads to changes in metabolism, pain perception and kinematic patterns, ultimately leading to excessive stress on passive structures in the musculoskeletal system (Freitag *et al.* 2007). An average of 66 events of trunk flexion were held for longer than 4 s throughout the day. These results suggest that pregnant women are exposed to stress from static postures.

4.4. Limitations

Several subjective tools, such as questionnaires and VASs for pain, were used to obtain the results of the first three objectives of this study. Subjective results represent a limitation because the data cannot be verified objectively. As such, this method to obtain the results represents the main limitation of the study in generalising the results.

The manufacturer reports an accuracy of $\pm 0.5^{\circ}$ for the VC under static conditions. However, the presence of accelerations in dynamic situations, such as the activities performed in this study, increases the error range for accuracy because the acceleration vector to which the angles are reported to can deviate from the line of gravity (Hansson *et al.* 2001). Nevertheless, it was shown that the errors for the angles reported by the VC were under 6° for similar accelerations (Beaucage-Gauvreau 2010). Although the accuracy is not excellent, this device represents a mean to obtain exploratory data on trunk postures of pregnant women in a field setting.

The instrumentation was not rigidly fixed to the subject's body; tape and a custom harness secured with adjustable elastic straps were used to attach the VC onto the subject's trunk. Therefore, incorrect angles can be reported if the instrument is displaced from its original position since all angles are reported relative to the subject's upright standing posture. However, no major shift in the instrument attached to the back was observed at the end of the day when the investigators returned to the subjects' homes to remove the VC.

Direct monitoring of head load carriage tasks and other occupational daily tasks was attempted by following the women throughout the day. However, this method proved to be unsuccessful as most subjects did not feel comfortable having a noticeable foreign person tracking their actions all day and would not perform their normal activities in her presence. After several attempts, the investigators decided that it would be best to stop the field observations to obtain a more representative set of data on daily trunk postures recorded by the VC.

5. Conclusions and recommendations

Fifty-eight percent of the pregnant subjects recruited in this study suffered from back pain since the start of their pregnancy. This study also showed that the pregnant subjects spent 36% of the recording time of approximately 8 h in trunk flexion above 20°. It was also found that the subjects bent down on average 328 times during data collection at angles exceeding 60°, with 66 of these bends lasting longer than 4 s. These postures are considered critical as sustained postures and repetitive movements increase the risk of musculoskeletal disorders.

Based on the observations of this study, the following four suggestions are recommended to reduce the risk of experiencing back pain during pregnancy for this population: (1) decrease the weight of the loads carried on the head; (2) encourage the team-lifting technique; (3) increase the number of breaks during the day and (4) avoid highly flexed postures during occupational tasks for long periods of time.

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