

Water bag: Technology to avoid head load of hill women

DEEPA VINAY, SEEMAKWATRA, SUNEETA SHRAMA and NIRMAL KAUR

Department of Family Resource Management, College of Home Science, G. B. Pant University of Agriculture and Technology, Pantnagar-263145 (U. S. Nagar, Uttarakhand)

ABSTRACT : Water fetching, fuel wood and fodder collection from far off distance are the three very important task which the hill women has to perform as a part of their livelihood besides bearing the other responsibilities (household & Agriculture). Fetching water is one of the most time devoting & heavy task performed by them throughout the year due to ever shrinking water resources and forest. It leads to great drudgery in terms of time and energy consumed and also the occurrence of occupational health hazards. The present study was designed with the objective to design a device/technology/ tool to reduce the physical & physiological strain while fetching water after collecting anthropometry measurement. Results shows that 20 lit of potable water can be carried in one trip by using water bag as compared to 9-10 lit of water by traditional method. The distance travelled in fetching water was reduced from 3km/day to 1.5km/day by the use of improved technology in terms of the amount of water fetch in one trip. A major decline in physiological parameters & musculoskeletal was also recorded by fetching water using improved method. Total Cardiac Cost of Work was reduced from 794.6 beats to 725.25 beats and Physiological Cost of Work was also found to be reduced from 132.43 beats to 120.87 beats. The respondents got relief from fatigue and pain by introduction of water bag as their perceived rate of exertion was reduced from the score of 4.5 to the score of 2.6.

Key words: Anthropometric measurements, fetching water, head load, musculoskeletal disorders

Uttarakhand hills in India stand out one of area where overwhelming number of women always been the part of active workforce due to their total involvement in domestic, agriculture, forest production, Cattle care & dairying. Most of the men folk in hill region have migrated to plains to earn their livelihood; therefore the women have to manage both their home and the farm. They are overburdened with heavy workload. Fulfilling basic needs like bringing water, fuel and fodder, which are getting more and more time consuming and difficult day by day due to ecological imbalance much of this work is monotonous, repetitive and physically tiresome in other word drudgery prone. So liberation from drudgery is needed, not only to give women much needed rest but relief from fatigue and pain and freedom from poor health and disease. The economy of hills is largely dependent on natural resources, and ever shrinking forest and water resources have hit women really hard. They spend longer hours gathering fuel, wood, fodder and fetching water which involve walking long distances in hilly regions with poor infrastructural facilities. All of these contribute to increase in the physiological costs and physical loads to a great extent. It also causes unbalancing of body with heavy loads. (Annual Report 1999-2000) and (Annual Report 2001-2002) Musculoskeletal discomfort are more common among women rather than men, especially the

neck and shoulder disorders due to carrying of load on their head. (Adams *et al.*, 2002) and (Nag *et al.* 2003) but anthropometric data on hill women (Uttarakhand) is negligible due to which mismatch occurs between human dimensions and dimensions of tools and equipments that Uttarakhand women uses. So it is essential to consider the gender and racial differences while designing the tools/ implements and equipment.

In views of the above facts and points it was proposed to investigate changes in the physiological responses and perceived exertion due to loads, modes, grades that are most critical factors in the hill women's life. Generation of anthropometric data on hill women is required to develop appropriate technologies for their better health and well being, and also the tools and equipment which either should be modified or designed considering, the anthropometric dimensions and capabilities of hill women.

The aim of this study was to develop technique to reduce the drudgery of farm women while fetching water and to identify potential health risk factors and gain insight into the health effects of the task to resolve their problem to a minimum.

MATERIALS AND METHODS

The present study was undertaken in hill region of Bhimtal block of Nainital district. Thirty physically fit respondents in the age group of 20-30 yrs and 31-40 yrs were selected for the study. Descriptive cum experimental research design was planned to collect the data on physiological stress and biomechanical analysis along with measurement of total cardiac cost of work and physiological cost of work. The data of whole activities of fetching water was collected as split up activity and as a complete cycle.

a) As split up activity

- i. Onward journey to the source with empty vessel(s) i.e. traditional as well as ergonomically designed water bag.
- ii. Drawing/pumping water.
- iii. Backward journey with filled vessel(s) to the storage place in the home.

b) As a complete Cycle: Fetching water was carried out completely in one cycle i.e. from onward journey with empty vessel(s) till respondent reached back and unloaded the filled vessel(s) at the destination. During the experiment, the working Heart Rate and Resting Heart Rate were recorded without any break.

PHYSIOLOGICAL STRESS ASSESSMENT

Polar heart rate monitor was used to record heart rate count per minute as $HR = \text{beats/min}$.

Energy expenditure was calculated using the formula:

$$EE (Kj/min) = 0.159 \times HR (\text{beats/min}) - 8.72$$

Bio-mechanical Assessment (analysis of the postural bends) & muscular stresses

Muscular stresses during the performance of the activity were measured by recording the incidences of pain perceived by the subjects in body parts along with the postural analysis and deviation of backbone from the normal by using body map and flexi curve. Intensity of pain in the above stated parts of the body was measured on five-point scale given below:

Score	Intensity of pain
5	Very severe
4	Severe
3	Moderate
2	Mild
1	very Mild

ASSESSMENT OF TOTAL CARDIAC COST OF WORK

Following formula was used to calculate the total cardiac cost of work (TCCW) and physiological cost of work (PCW) (Singh *et al.*, 2007).

Total cardiac cost of work = cardiac cost of work + cardiac cost of recovery.

$TCCW = CCW + CCR$; where

$CCW = AHR \times \text{Duration of activity}$

$CCR = (\text{Avg. recovery HR} - \text{Average resting HR}) \times \text{Duration}$; where

$AHR = \text{Avg. working HR} - \text{Average resting HR}$

ANTHROPOMETRIC MEASUREMENTS

Anthropometric measurements of the respondents were gathered using anthropometric kit in order to design tool/technology which would help and give support to the respondents in fetching water in hill region of Uttarakhand without drudgery.

RESULTS AND DISCUSSION

Water is the most essential but scare resource in most of the region of our country. The demand for water has increased to the extent that tremendous pressure on water resources has led to the disturbance of water level in over all environments and to the places where natural water source suffice the need of habitant living in those areas especially in hill region. The present investigation aimed to study the existing way to collect and fetch water to suffice domestic needs and to find out the suitable technique to fetch water with less effort.

ACTIVITY PROFILE OF FETCHING WATER

a) Type of vessel: Results showed that majority of the respondent used Iron bucket (80%) mainly to fetch water followed by Jerry cane (20%). The average weight of Jari cane was 1 kg whereas weight of Iron bucket ranged from 3-4 kg. (Table-1)

b) Mode of carrying load: Head load was the most frequent mode of carrying water to home and besides this sometimes it has been also seen that women fetch water in bucket by holding it in hands. A woman carried one vessel at a time having a load of 3.25 kg (for Iron bucket) and 1 kg (for jerry cane) during onward journey. Respondents carried 9.2 kg

(when Iron bucket was used) and 10 kg (when jerry cane was used) with water filled vessel during return journey of fetching water (Table 1). Water filled containers are often carried on the head or in hand depending upon the type of vessel used to fetch water. These methods obviously create physical demands on the body and the potential for adverse physical stress due to regular carrying of water loads. Similar study conducted by (Hyderabad AICRP 2001-2002) team reported shoulder as the mode of fetching water.

- c) Number of vessels:** On an average, a woman fetched minimum of 6 vessels of water daily in summer season (Table 1). Which suffice the purpose of cooking and drinking for the whole family. Hence, women had to make 6 trips per day to fetch water.
- d) Time spent:** On an average woman spent 20 min. per trip to fetch one vessel of water from nearby areas to home (Table 1). Hence, the total time spent per day on fetching water was 120 min.
- e) Distance traveled:** The women traveled a distance of 0.50 km per trip of fetching water (Table 1). This depicts that women had to travel 3.0 km in a day for fetching of water only.

- f) Speed of walking:** The women walked at the speed of 2.0 km/hr during onward journey of fetching water whereas the walking speed was found to reduce to 1.5km/hr for backward journey because of the volume of water filled in vessel and uneven passage of hill areas.

ANTHROPOMETRY FOR DESIGNING OF WATER BAG

Assessment of the anthropometric measurements (mean, standard deviation and various percentiles values) of Uttarakhand women reveals that mean height, shoulder height, elbow height while standing were 151.49 (± 5.93), 126 (± 5.12), 97.16 (± 5.23) cm respectively. It can also be envisaged from the table-2 that shoulder breadth, chest breadth, elbow-elbow breadth and standing hip breadth were 35.86 (± 2.81), 27.72 (± 2.30), 42.25 (± 4.10), 38.10 (± 4.67), 28.21 (± 3.06) cm respectively. It can also be seen that the chest and waist circumferences were 82.10 (± 6.50) and 70.59 (± 7.44) cm respectively. On the basis of all these anthropometric measurements the height of bag was made 42 cm, width 38 cm and thickness was made to 19 cm. The material for water bag was decided to be of synthetic leather (Racxin) with plastic jerry cane by which water can be carried on the back. It has broad straps to hang the bag which gave support and very convenient to carry the load (Figure 1).

Table 1: Activity Profile of Hill Women of Uttarakhand

Type of vessel	Iron Bucket	80%
	Jerry Cane	20%
Mode of carrying load	On head	60%
	In hands	40%
Weight of vessel	On word journey (empty vessel)	3.25 kg (Iron Bucket) 1kg (Jerry Cane)
	Backward journey (Filled vessel)	9.2 kg (Iron Bucket) 10 kg (Jerry Cane)
Number of vessels	6 vessels/day	6 trips/day
Time spent	20 minutes/trip	120 min/day
Distance traveled	0.50 km/cycle	3.0 km/day
Speed of walking	2.0 km/hr (during onward journey)	1.5 km/hr (during backward journey)

Table 2: Anthropometric measurements of Hill Women of Uttarakhand

Sl.No.	Measurements (cm)	Mean	5 th	50 th	95 th
1.	Height	151.49 (± 5.93)	141.9	152.0	161.0
2.	Shoulder Height	126.00 (± 5.12)	119.0	125.0	135.0
3.	Elbow height	97.16 (± 5.23)	89.9	98.0	104.0
4.	Shoulder breadth	35.86 (± 2.81)	32.0	35.0	41.0
5.	Chest breadth	27.72 (± 2.30)	24.0	28.0	31.0
6.	Maximum body breadth	42.25 (± 4.10)	35.0	43.0	48.0
7.	Elbow-elbow breadth	38.10 (± 4.67)	31.0	39.0	45.0
8.	Hip breadth standing	28.21 (± 3.06)	25.0	28.0	35.0
9.	Chest circumference	82.10 (± 6.50)	72.0	82.0	94.0
10.	Waist circumference	70.59 (± 7.44)	60.0	70.0	84.0

Values in parentheses indicate the standard deviation of mean



Fig.1

Physiological Stress: Physiological stress of women respondents was determined on the basis of various parameters like:

- a) **Heart Rate:** Table-3 shows that the average HR (max) was higher in case of traditional method of fetching water i.e. 142.5 beats/min (SD±9.34) as compared to improved method (131.5 beats/min and SD±8.29).
- b) **Energy Expenditure:** When average and peak energy expenditure was calculated for both type of methods it was found that values for average and peak E.E. in case of improved method was lower (9.65 Kj/min) and (12.18 kj/min respectively) as compared to traditional method (Table-3). The values for Total Cardiac Cost of Work (794.6 beats),

Physiological Cost of Work (132.43 beats) and Rate of Perceived Exertion was found higher (4.5) in case of traditional method whereas values were found lower for improved method. Comparative study of quantity of volume of water carried shows that 20 lit of water can be carried in one trip in improved method whereas 10 lit of water was carried by traditional method (Figure 2).

BIOMECHANICALASSESSMENT

- a) **Postural Analysis:** The spinal curvature at cervical and lumbar regions was recorded while onward journey, drawing water and backward journey during fetching water.
 - i. **Frequency of postural change:** Bending posture was adopted for maximum number of times (40) during drawing of water from the hand-pump (Figure-2) while fetching water followed by standing and squatting posture.



Fig. 2

Table 3: Physiological workload while fetching water by Hill women of Uttarakhand with traditional and improved method (Water Bag)

Sl.No.	Parameter	Traditional Method	Improved Method (Water Bag)
1.	H.R. rest beats/min	78.17 (±7.38)	81.25 (±6.65)
2.	HR. avg beats/min	125.38 (±10.55)	115.55 (±8.24)
3.	HR. max beats/min	142.5 (±9.34)	131.5 (±8.29)
4.	E.E. avg Kj/min	11.28	9.65
5.	E.E. peak kj/min	13.93	12.18
6.	TCCW beats	794.6	725.25
7.	PCW beats	132.43	120.87
8.	RPE	4.5	2.6
9.	Quantity of Water carried (lit)	9-10	20

Values in parentheses indicate the standard deviation of mean

b) Spinal curvature at cervical and lumbar region:

Table 4. Show the average cervical and lumbar angles obtained while onward, backward journey & drawing water by women during fetching water. The angles were recorded to study the effect of bending on anterior & posterior spinal curvature. Percentage deviation in the cervical region from the normal position was assessed to be 1.7 and 7.3 per cent while drawing water among women belonging to two age groups viz., 21-30 yrs. & 31-40 yrs respectively. It was 2.9 and 3.1per cent respectively in two age groups during backward journey respectively. In lumbar region (Figure-3), percentage deviation from normal position was quite significant in case of drawing water among both age groups (10.0 per cent and 8.9 per cent respectively). It was assessed to be 2.9 and 3.5 percent during backward journey for the women belonging to 21-30 yr. and 31-40 yr. of age respectively. It is evident that the anterior- posterior spinal increases during carrying load while it decreases during drawing water. Respondents complained of fatigue during work and also towards the end of the day. Postural stress could be a causative factor for high physiological cost and

fatigue. This might lead to vertebral column related injuries or health problems in the long run which is evident from the body ache and pain (Nykanen *et al.*, 2007) similar trends was reported by (Joosab *et al.* 2004) physical loading of the body within an individual's capacity for adaptive responses may lead to tissue strengthening, however, frequent loading beyond capacity for adaptation or repair may lead to injury through fatigue, accumulation of fatigue damage or early degenerative changes in bone and soft tissues.

c) **Musculoskeletal Problems:** To study the musculoskeletal problems, a body map was used to analyze the magnitude of body pain of women while fetching water. Figure-4 showed the intensity of pain in various body parts of the hill women of Uttarakhand while carrying loads. In present investigation in traditional method about 79 percent of the respondents reported the problem of back pain followed by body pain (70 Per cent) and shoulder pain. The back was the most affected part of the body while fetching water as reported by Waddell, 2004. When the work was performed in traditional way

Table 4: Percentage deviation in the spinal curvature

Deviation in the cervical region from normal	20-30 years (Women)	31-40 years (Women)
While drawing water	1.7%	7.3%
During backward journey	2.9%	3.1%
Deviation in the lumbar region from normal		
While drawing water	10%	8.9%
During backward journey	2.9%	3.5%

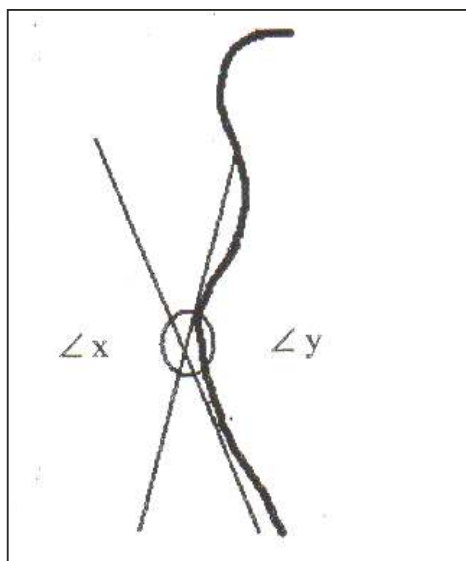


Fig. 3

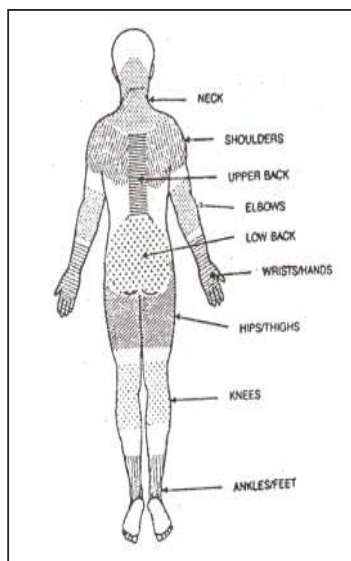


Fig. 4

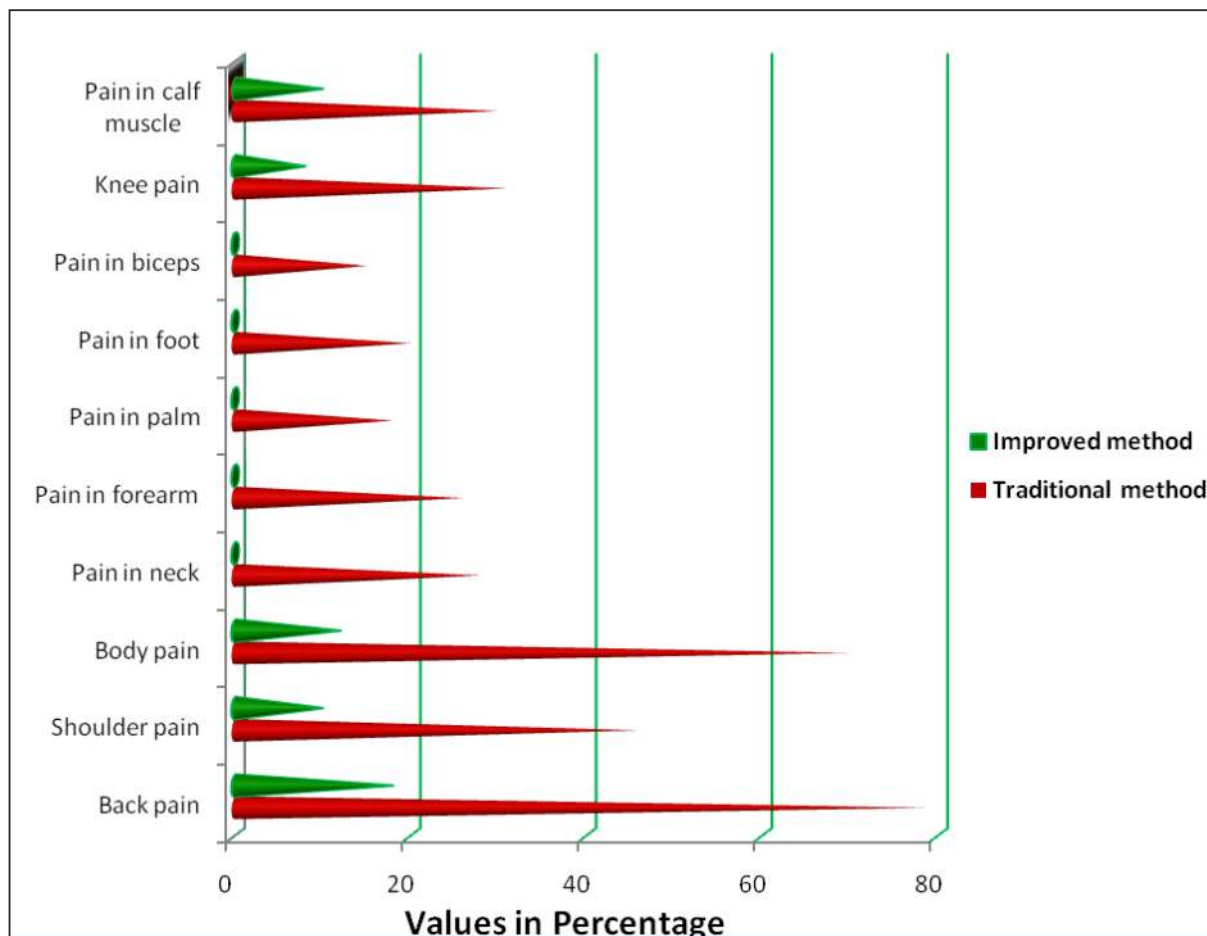


Fig. 5: Musculo-skeletal problems among hill women

pain in neck, forearm, palm and feet was also reported by some of the respondents (Figure-5) but the intensity of pain was lower as compared to back, shoulder and body pain. By introduction of water bag for fetching water i.e. in improved method occurrence of the back pain was reported by 18 per cent of respondents followed by 12 per cent (body pain) and 10 per cent (shoulder pain). Occurrence of pain in calf muscles and knee was reported by 30 per cent of respondents performing the task with traditional method which was reduced to 8-10 per cent when the same task was performed using water bag.

Assumptions have been made that water carrying is detrimental to health and associated with musculoskeletal disorders, such as spinal pain or other joint problems (Punnet *et al.*, 2000). Such assumptions are supported by strong evidence that the physical demands of work such as handling

heavy materials, bending, twisting and lifting, are risk factors for onset of simple low back pain and other musculoskeletal disorders (Buckle *et al.*, 2002).

CONCLUSION

This study has highlighted the potential association between back pain and water carrying in Hill region of Uttarakhand. This association is complex with water carrying probably contributing to the etiology of spinal pain which interfere with people's ability to carry water and potential impact on household water availability. Typical methods of carrying water containers as observed in this study imposes physical load with potentials to produce symptoms like musculoskeletal disorders and related disorders. Risk of musculoskeletal injury or pain may be high for women covering distance together with total volume or weight of water and path gradient. It indicates the level of physical workload imposed by work of water carrying.

Identifying risk factors for musculoskeletal disorders and pain related to water carrying pressurized to develop appropriate interventions

As our preliminary findings highlights the potential impact of carrying water by traditional method may have adverse effect on health, in particular along with the symptoms, such as neck pain, back pain and other related functional discomfort. This is an important but neglected public health issue which should be monitored by evolving appropriate interventions to reduce the risk exposures. Therefore, need was felt to develop and designed a device called water bag for fetching water in hilly terrain with a capacity of 20 liters of water. This device came to be perfect options as work of carrying water becomes less tiresome, easy and less time consuming. Thus time saved can be used to carry out other daily household chores hence developed water bag is a solution to the back and neck pain of the water carriers will potential increase in productivity.

REFERENCES

- Annual Report (1999-2000). Ergonomics of Farm Women's Drudgery- All India Co-ordinated Research Project in Home Science, Department of FRM, COHS, CCSHAU, Hisar: 1-80.
- Annual Report (2001-2002). Ergonomics of Farm Women's Drudgery- AICRP in FRM Acharya N.G., Ranga Agricultural University, Rajendranagar, Hyderabad: 1-95.
- Adams M, Bogduk N, Burton K, Dolan P. (2002). *The Biomechanics of Back Pain*. Edinburgh: Churchill Livingstone;.
- Buckle P.W., Devereux J.J. (2002). The nature of work-related neck and upper limb musculoskeletal disorders. *Appl Ergon.*;33:207–217. doi: 10.1016/S0003-6870(02)00014-5.
- Joosab M, Torode M, Rao PV. (2004). Preliminary findings on the effect of load carrying to the structural integrity of the cervical spine. *Surg Radiol Anat.* ;16:393–398. doi: 10.1007/BF01627659.
- Nag, Anjali, Nag P.K. and Desai, Hina. (2003). Hand anthropometry of Indian women. *Indian Journal of Medical Research*, 43 (6): 162-167.
- Nykanen M, Ylinen J, Hakkinen A. (2007). Do cervical degenerative changes in women with chronic neck pain affect function? *J Rehabil Med.*;39:363–365. doi: 10.2340/16501977-0075.
- Punnet, L. and Herbert, R. (2000). Work related musculoskeletal disorders. In there a gender differential and if so does it means? In: Goldman, M., Hatch, M. (eds), *Women and Health*, PP. 474-492.
- Waddell G. (2004). *The Back Pain Revolution*. 2. Edinburgh: Churchill Livingstone.

Received: July 10, 2019

Accepted: July 31, 2019