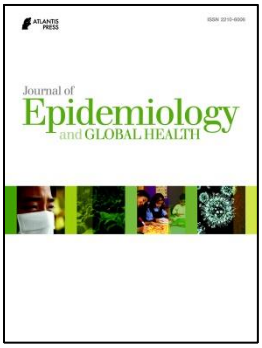

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Evaluation of physical fitness and weight status among fisherwomen in relation to their occupational workload

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KEYWORDS
Physical fitness;
Harvard step test;
Anaerobic power;
Body fat;
Visakhapatnam

Abstract *Background:* Fisherwomen contribute significantly to the coastal economy of Eastern India; however, data about their physical fitness and weight status are scant.

Objectives: The present cross-sectional study was designed to investigate cardiorespiratory fitness and weight status of fisherwomen, which may be influenced by their occupational workload, using morphometric and anthropometric measures.

Methods: The study was conducted among young fisherwomen (mean age 23.7 years) randomly selected from Araku, Visakhapatnam, Andhra Pradesh, and among young women who are not engaged in the fishing industry but are residents of Araku, who served as controls (mean age 21.3 years). Measurements of body composition included several anthropometric variables, while physical efficiency parameters included a physical fitness index (PFI), VO_{2max}, total energy expenditure, and anaerobic capacity.

Abbreviations: BC, Buttock Circumference; BMI, body mass index; BSA, body surface area; CC, Calf Circumference; CED, chronic energy deficiency; CHD, coronary heart diseases; FPA, female physical attractiveness; HST, Harvard step test; MUAC, Mid Upper Arm Circumference; PBF, Percentage of body fat; PFI, physical fitness index; SDA, specific dynamic action; TC, Thigh Circumference; TEE, total energy expenditure; VO_{2max}, maximal aerobic capacity; WC, Waist Circumference; WHR, waist-to-hip ratio.

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Results: A significant difference ($p < 0.05$) in body mass index (BMI), body surface area (BSA), body fat percentage, diastolic blood pressure, fitness index, total energy expenditure, and anaerobic power was found in fisherwomen compared with controls. Analysis of collected data showed that the majority of the fisherwomen studied have a normal range of BMI (42%), but 6% of them were found to be mildly overweight. They also showed lower fat mass (13.5 [±3.87] kg) and lower waist-to-hip ratio (WHR) and conicity index. Additionally, they were found to have a moderate level of physical fitness (64.3 [±1.97]%) and a higher total energy expenditure (4.92 [±0.52] k.cal.min^{-2}).

Conclusion: This study implies that physical fitness and weight status of young fisherwomen in Eastern India are influenced by their occupational workload.

1. Introduction

The fisheries sector occupies a very important place in the socioeconomic development of a country [1]. It has been recognized as a powerful income and employment generator as it stimulates the growth of a number of subsidiary industries. It is also a source of cheap and nutritious food besides being a foreign exchange earner. Most importantly, it is the source of livelihood for a large section of the economically backward population of a country. Thus, fisheries form the most important resource for communities inhabiting coastal regions, and it provides a major source of livelihood for them [1].

In India, women constitute about 50% of the population and comprise one-third of the labor force. Women contribute significantly to the fishery sector of the Indian economy. Out of the 5.4 million active fisher folk in India, 3.8 million (70.4%) were fishermen and 1.6 million (29.6%) were fisherwomen [2]. Besides attending to routine family chores, coastal women also support the fisheries sector through their involvement in various operations of small-scale fisheries (Table 1). Women constituted an estimated 25% of the labor force in pre-harvest activities of fish, 60% in export marketing, and 40% in internal marketing [3]. Women are also actively involved in the collection of bivalves and their marketing to ornamental dealers and lime collectors [1]. In Visakhapatnam (*the Jewel of the East Coast*), the residents are mainly engaged in agriculture, fishery, animal husbandry and industries. Fishery is an important economic activity of this district; the fisher population is spread over about 59 fishery villages and hamlets along the coastline stretching to a length of 132 km, covering 11 coastal mandals (districts). About 13,000 fisher families eke out their livelihood from marine, inland and brackish water fishing [4]. Fishing communities are almost solely dependent on the sea resources for their livelihood and the roles a fisherwoman plays are integral to the maintenance and economic prosperity of the family. Women are mostly engaged in peeling, trading, processing and various other activities in the post-harvest sector of fisheries.

The people residing in the coastal regions of Visakhapatnam who are engaged in the fishing industry are supposed to be affected by the workload of this energy-demanding occupation on their physical fitness [5]. Thus, it is evident that their occupation demands a higher level of physical fitness, but the physical fitness data of fisherwomen of India are quite scanty. In adults, a low level of physical fitness (mainly cardiorespiratory fitness) seems to be a stronger predictor of both cardiorespiratory and all-cause mortality than any other well-established risk factors [6,7]. Thus, the present study focuses attention on determining the physical efficacy of the local people engaged in the fishing industry and also on determining the influence of the occupational workload over certain fitness parameters of young women engaged in the fishing industry and who reside in Araku valley in Visakhapatnam district. Thus, this study was carried out to test the hypothesis that physically demanding occupations have an influence over the physical fitness pattern of workers.

2. Methods and materials

Respondents of this small-scale study included young women of Araku valley, Visakhapatnam. Respondents were divided into two groups: for the first group, 50 young fisherwomen (aged 23.7 ± 2.85 years) of the Araku valley of Visakhapatnam District, Andhra Pradesh, were randomly selected to participate. In the second group, 50 age- and sex-matched control subjects (aged 21.3 ± 2.34 years) were also randomly selected from the Araku Valley to minimize the ethnicity

Table 1 Women's range of work within the fisheries and within the fishing communities.

As workers within the fisheries (paid and unpaid)	Women may work in fish marketing, in the preparation of bait, making and repairing nets, collecting crabs and shellfish, gathering and cultivating seaweed and algae, in smoking, salting and drying fish, and, in rare cases, fishing. They may also work in aquaculture farms. Often ignored is the 'liaison work' many wives of fishermen undertake on behalf of their fishermen husbands, such as dealing with financial institutions for credit for fisheries operations
As workers in processing plants	Women are very active in the processing sector, as either part-time or full-time workers in processing plants, or workers under sub-contracting systems
As those responsible for the family and community	Women, as everywhere else, are almost entirely responsible for the care and nurture of the family. Where the men stay away fishing for long periods, women run the household in the absence of their husbands
As workers outside the fisheries	Often, women of coastal fishing communities take on activities outside of the fishery that give them some form of stable monetary income, since the income from the fishery is inherently unstable and unpredictable

differences. Control subjects included students or housewives of nearby villages of the same socioeconomic class who were not engaged in any type of fishery-related jobs. The entire experimental protocol was explained to them to allay their apprehensions. Consent from each participant was taken for conducting the study and the experiments were carried out following Institutional ethical permission. Subjects were instructed to take their last meal at least two hours before conducting the test in order to avoid the specific dynamic action (SDA) of food. All the experiments were carried out, and measurements were taken at a temperature of 20–25 °C and a relative humidity of about 45–50% in the winter season in India to avoid the seasonal influence on fitness patterns. To minimize the experimenter bias, each measurement was taken three times, and the mean was represented as the final result.

The body mass index (BMI) was measured by the following formula [8,9]: BMI = mass (kg)/(Height in m^2). Body fat percentage was also estimated by a predictive formula using BMI, age and gender [10]: Adult Body Fat % (PBF) = (1.20 × BMI) + (0.23 × Age) − 5.4 (for female subjects). This formula has the variability of 5–10% [10]. The formula of Banerjee and Sen was used for estimating body surface area (BSA) [11].

The resting heart rate was recorded after five minutes of rest at carotid pulse. When two successive heart rate scores become equal, then it was considered as the resting heart rate [12]. Arterial blood pressure was measured by using a sphygmomanometer [13].

The physical fitness index (PFI) was calculated by measuring the heart rate after performing the Harvard step test (HST) developed by Brouha et al. [14]. It was first developed in the Harvard Fatigue Laboratories using the long form of the PFI equation, but, following modified HST under Indian conditions, using a stool 51 cm high and stepping up and down at a rate of 30 cycles/minute for 3 min or up to exhaustion. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 s. After completion of the test, peak heart rate was recorded, and the recovery pulse was counted at 1–1.5, 2–2.5 and 3–3.5 min of recovery. Then the duration of exercise (in seconds) was divided by the sum of recovery heart rates to get the PFI. This is generally expressed in percent values. It has also provided a reference range that if the PFI value (%) is below 40, the fitness of the subject is very poor; if it is 41–50, the physical fitness is poor; if it is 51–60, the fitness is average; 61–70 indicates good fitness; 71–80 indicates very good physical fitness; and a PFI value (%) above 80 shows excellent fitness. Harvard step test for PFI has the variability of 5–10% [14].

To calculate the anaerobic power, Margaria Double Step test was carried out [15]. It is a short-term anaerobic test or a power test in which the subject climbs two steps at a time; the height of the stairs is measured by a measuring tape. To calculate the anaerobic power, the height of ascent, the body weight, and the duration (seconds) are noted by the stopwatch. The work done is calculated by the following formulae: Work done (kg/meter) = body weight × height of ascent × 0.002342. Then the work done was divided by the duration of the work (in seconds) to get anaerobic power (kg/meter/s). Margaria Double Step test for anaerobic power has the variability of 5–6% [15].

VO_{2max} was estimated by using peak and resting heart rates [16]. Total energy expenditure (TEE) has also been determined by another predictive formula using peak heart rate scores recorded during HST [17]: TEE (kcal min^{-2}) = −1.42 + (0.045 × peak heart rate).

Circumference measures were taken around the midpoint of the upper arm (MUAC), thigh (TC), calf muscle (CC), waist (WC) and buttock (BC) by anthropometric tape. WC and BC are used to predict the body fat content. Eleven derived variables—body surface area (BSA), body mass index (BMI), body adiposity index (BAI), fat mass (FM), fat mass index (FMI), fat free mass (FFM), fat free mass index (FFMI), waist-to-height ratio (WHTR), waist-to-hip ratio (WHR), MUAC-to-height ratio (MHR) and conicity index (CI)—were included. All anthropometric measurements were made by using standard anthropometric techniques [18].

All used formulae are as follows [18].

FM (kg) = body weight (kg) [PBF/100].
FFM (kg) = weight (kg) − FM (kg).
FMI (kg/m^2) = [FM (kg)/$height^2$ (m^2)].
FFMI (kg/m^2) = FFM / $height^2$ (m^2).
BAI = [hip circumference (cm)/(height $\sqrt{height}$)] − 18.
CI = Waist circumference (m)/0.109 $\sqrt{weight\ (kg)/height\ (m)}$.

Results were expressed as mean (±SD). If differences between groups were established, the values of the treated groups were compared with those of the control group by a modified *t*-test. To carry out the analysis of the data statistically SPSS v.15.0 and MS-Excel v.2013 were used. A value of $p < 0.05$ was interpreted as statistically significant [19].

3. Results

Table 1 describes the work roles of fisherwomen in the fishing industry. They are engaged in different levels of fishery and at processing units in the industry. In Table 2, the sociodemographic data of the studied population are represented. The results of both physical and physiological parameters are represented in Table 3. The height (cm) and body weight (kg) of 50 control female subjects are 157.2 ± 4.23 and 54.9 ± 5.14, respectively, and those of young fisherwomen of the Araku valley are 153.5 ± 2.09 and 46.2 ± 4.18, respectively. The anthropometric parameters that indicate the weight status of the studied population based on PBF, WC, and WHR are presented in Table 3, which also represents comparative aspects of physical variables (BSA and BMI). Fisherwomen were found to have significantly lower BMI values [19.6 (±2.61) kg/m^2] than the control subjects [22.2 (±3.03) kg/m^2]. The results indicate moderate body weight with respect to height in female fishers (according to WHO weight-to-height tables), but the fat distribution is quite higher in non-fishing female residents of Araku. The cutoff points for obesity were adopted as recommended by Dudeja et al. [20] for PBF (⩾30.0%), Dasgupta and Hazra [21] for WC (⩾72.0 cm), and Rahim et al. [22] for WHR (⩾0.85). PBF (though <30.0%), FM, FMI, and BAI are higher in control females, which indicate an increased inclination toward being overweight.

Table 2 Socio-demographic data of fisherwomen of Araku valley, Visakhapatnam District.

Total population (As per 2001census)	55,959
Total males	28,277
Total females	27,682
Growth(1991–2001)	15.36%
Total no. of women involved with fishery and related jobs	20,493
Per capita income (Rs.)	8455.25
Total literacy rate	44%
Total percentage of fish eaters	65

Table 3 also represents several common physical fitness variables of female fishers. Based on their PFI, they showed good physical fitness (i.e., between the cutoff values of 61 and 70) [14]. But in all other parameters, they were within the normal range. The two groups showed significant differences for almost all these parameters. It also represents the comparative aspect of anaerobic power, total energy expenditure, and predicted aerobic capacity (VO_{2max}). Young fisherwomen of Araku demonstrated greater anaerobic power and VO_{2max}, but less expenditure of energy for a specific task than did the control subjects. Strenuous physical activity requires enormous bodily movement produced by the skeletal muscles that requires energy expenditure. Individuals who use less energy than others for a specific kind of work are said to be more fit. In this study, for the same kind of work as performed by both groups (control and fisherwomen) in HST for 3 min, fisherwomen were found to exert less energy than control subjects, which indicates that their level of physical fitness is higher than that of the control subjects.

The frequency of overweight and underweight fisherwomen is presented in Table 4. The overall prevalence of obesity (BMI > 30.00) was completely absent in the studied sample (both in normal residents, as well in fisherwomen); only 6% of the fisherwomen were found to be mildly overweight compared with the control group (14%). However, most of the fisherwomen were found to be within the normal range for body weight, on the basis of

Table 3 Body compositions and physiological parameters indicating physical fitness and endurance of the studied population.

	Control		Fisherwomen		p values
	Mean	SD	Mean	SD	
Age (years)	21.3	2.34	23.7^{NS}	2.85	0.101
Body composition					
BMI (kg/m^2)	22.2	3.03	19.6*	2.61	0.024
PBF (%)	26.1	2.70	23.52*	3.66	0.027
BSA (m^2)	1.54	0.32	1.41*	0.24	0.048
Physiological parameters					
Resting heart rate (beats/min)	78.6	7.14	84.1†	5.41	0.031
Systolic blood pressure (mm of Hg)	121.2	3.54	118.0^{NS}	4.99	0.069
Diastolic blood pressure (mm of Hg)	82.2	5.16	78.3†	4.50	0.043
PFI (%)	57.6	3.90	64.3†	1.97	0.003
Anaerobic power (kg.m^{-1}.sec^{-1})	11.7	3.42	14.2$^\#$	3.21	0.038
VO_{2max} (ml/kg/min)	31.0	2.33	35.0$^\#$	3.57	0.033
Energy expenditure (k.cal.min^{-2})	5.61	0.72	4.92$^\#$	0.52	0.007
Adipocity measures					
Fat mass (kg)	14.3	4.18	13.5†	3.87	0.037
Fat mass index (kg/m^2)	6.09	1.88	5.70†	1.77	0.021
Fat free mass (kg)	50.6	4.08	33.1†	4.26	0.024
Fat free mass index (kg/m^2)	17.29	1.68	15.30†	1.86	0.077
Body adipocity index	34.08	5.46	30.09†	4.62	0.046
Waist-to-hip ratio (WHR)	0.87	0.02	0.84†	0.03	0.043
Waist-to-height ratio (WHTR)	0.45	0.01	0.42^{NS}	0.02	0.546
MUAC-for-height (MHR)	0.14	0.01	0.12^{NS}	0.02	0.483
C-index	1.07	0.06	1.02†	0.06	0.034
Morphometric characters					
Mid Upper Arm Circumference (cm)	22.2	2.91	20.5^{NS}	2.52	0.093
Thigh Circumference (cm)	42.3	3.90	39.0§	2.13	0.046
Calf Circumference (cm)	28.6	3.20	27.6^{NS}	3.03	0.123
Waist Circumference (cm)	70.4	6.80	66.3§	5.22	0.047
Buttock Circumference (cm)	80.3	5.73	78.9^{NS}	4.62	0.076

Values are mean ± SD ($n_1 = n_2 = 50$); values bearing superscripts are significantly different; NS = not significant.

BMI. Among 50 fisherwomen, 42% had a BMI within the normal range. Here it should be mentioned that all these estimations are based on an indirect technique, i.e., anthropometry and the International Classification of BMI cutoff points [23].

4. Discussion

Among fisherwomen of the coastal areas of Visakhapatnam, who, according to Dehadrai, work as '*invisible farmers*' in spite of producing food in terms of value, volume, and hours in fishery and allied activities [3], physical parameters indicate that their body compositions (BMI, BSA, PBF) showed significant differences compared with a control group of their peers. Their body weights were found to be significantly lower than those of young females who served as controls. Young fisherwomen were also found to have significantly less PBF than the sedentary population (Table 3), which may be attributable to their age; hence, they have a propensity for being lean rather than obese [24]. In Andhra Pradesh, more than 30.8% of women are reported to be underweight, a percentage that ranks Andhra Pradesh number 14 among the 28 states of India [25]. Concomitantly, their BMI values are also found to be significantly lower. It has been reported previously that the women of the East Coast of India who are engaged in fishery and fishing related occupations, irrespective of their status, spend more than 14–18 h daily at hard, monotonous work [26]. It has also been reported that there is a severe chronic energy deficiency (CED) in fisherwomen [3].

Table 4 presents the distribution of all subjects according to BMI classification. BMI is considered a better index for assessing obesity because it eliminates the need for height–weight tables and is independent of type of body frame; furthermore, it can be used to estimate the prevalence of obes-

Table 4 Distribution of BMI and prevalence of thinness and obesity among fisherwomen of Visakhapatnam, Andhra Pradesh.

Group	Sample size	Overweight (and obesity)			Normal	Underweight (thinness)		
		Grade III: severe	Grade II: moderate	Grade I: mild		Grade I: mild	Grade II: moderate	Grade III: severe
		(BMI >40)	(BMI 30–39.99)	(BMI 25–29.9)	(BMI 18.5–24.9)	(BMI <18.49)	(BMI 17.0–18.49)	(BMI 16.0–16.99)
Control	50 (100)	0 (0.00)	0 (0.00)	7 (14.00)	42 (84.00)	1 (2.00)	0 (0.00)	0 (0.00)
Fisherwomen	50 (100)	0 (0.00)	0 (0.00)	3 (6.00)	21 (42.00)	14 (28.00)	11 (22.00)	1 (2.00)

Figures in parenthesis indicates percentage.

ity within a population [27]. Therefore, in the present study, the body composition of female fishers was calculated according to the critical limits of BMI as recommended by WHO [27]. Although only 2% of the fisherwomen are reported to be severely underweight, it is of great concern that the percentage of underweight females is greater among fisherwomen (28% mildly, 22% moderately, and 2% severely underweight) than controls, which is reflective of their poor nutritional status. However, it was also observed that most of the fisherwomen have a normal BMI (42%), but the results of control females indicated a higher propensity for obesity than fisherwomen. In this present study, it has been found that control subjects who are not exposed to such heavy workloads tend to be obese more often than fisherwomen (14% of overweight females are found in the control group and 6% among fisherwomen).

Physical fitness comprises two related concepts: general or static fitness (a state of health or well-being) and specific dynamic fitness (related to task-oriented fitness). In this context, aerobic capacity (VO_{2max}) has widely been considered to be a reliable and valid measure of physical (cardio-respiratory) fitness [28] and endurance; as VO_{2max} increases, this indicates greater respiratory capacity and thus better cardio-respiratory fitness. In this cross-sectional study, a significantly higher VO_{2max} was observed in fisherwomen. Such physical differences may be attributed to their lifestyle and occupational needs, which require extra energy expenditure for their daily activities, resulting in some adaptive changes [29]. However, the results of the present study show that changes in systolic and diastolic blood pressure, as recorded, were not concomitant with the earlier findings of Astrand [16] and Kanstrup et al. [30]. In the present investigation, both systolic and diastolic blood pressures were found to be lower in fisherwomen, among which only diastolic pressure showed significant differences in subjects. In contrast, the earlier studies of fishermen showed higher RHR and blood pressure values [5,24]; the decreased RHR and blood pressure values in women may be due to their cardiac autonomic modulation, as they have lower sympathetic activity compared with healthy men, which provides protection against arrhythmias and against the development of coronary heart diseases (CHD) [31].

For a specific workload, it has been proposed that the better the health status of the individual, the more rapid will be the return of the heart rate to its resting level, and consequently results in lower recovery cardiac costs [14,32]. Similar results were found in fisherwomen, where the return of the heart rate to its resting level was more rapid than that of control subjects. Moreover, the peak heart rate is lesser in comparison to control subjects, indicating better physical conditioning in the fisherwomen group. Their pulse rate recovered quickly, which is also an indicator of better fitness and is reflected in significantly higher PFI and lower energy expenditure. In addition, they demonstrate better anaerobic power than sedentary workers (Table 3). These data suggest that young fisherwomen have good cardiorespiratory fitness.

Table 3 also shows various physical parameters and obesity indicators, among which female fishers have shown lower BSA due to their shorter stature. They also showed lower PBF, fat mass, fat mass index, and body adiposity index than the cutoff values, which are indicators of their overall lower fat distribution compared with control females. It is also noted that body fat is related to BMI [33]. Thus, there may be an association between their lower BMI and lower amount of body fat. They also showed significantly lower fat free mass and C-index, which indicates lower abdominal fat and muscle mass distribution. These results indicate an overall higher fat distribution in control females than in fisherwomen, but fisherwomen have much lower fat distribution in their abdominal regions. Anthropometry is one of the methods used in nutritional assessment. From a public health perspective, it is the most valid measure for the identification of subclinical forms of malnutrition [29]. The information can reflect the socioeconomic and nutritional status of the respondents. In the present study, although fisherwomen perform more work related to strength than control females do, they are not found to have more MUAC (Table 3), which is an estimate of energy storage and protein mass of the body and an indirect estimate of strength [34]. Waist circumference as well as waist-to-hip ratio [35—37] is found to be significantly lower in fisherwomen than in control subjects and is another indicator of lower fat percentage in young fisherwomen than in control subjects; this may be related to their poor socioeconomic status. Of these two parameters, waist circumference is considered to be a better index for fat location than WHR for predicting lipid profile in adult women [38]. However, it is a well-known fact that BMI also has a negative correlation with WHR, which is very important in the case of women because this interrelation is a cue to female physical attractiveness (FPA) and the beauty of women [39].

5. Conclusion

The preceding discussion makes the things clear that the women who spend long hours in performing time-consuming and labor-intensive works in fisheries, residing in the coastal regions of Visakhapatnam district, India, have better health and physical fitness than the control subjects. Their occupational workload has a positive influence over their physical and physiological parameters. However, the findings of the present study also describe that almost 1 of 2 female residents of Visakhapatnam (26 out of 50 participants) are underweight, which is indicative of their poor nutritional status with respect to their workload. Therefore, appropriate precautionary measures should be taken to prevent the further progression of the problem into the younger members of the population.

Conflict of interest

Authors declare that they do not have any conflict of interest about the publication of this article.

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