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Physical exertion and trunk movements of early elderly females carrying 3 liters of water in different capacity water bags

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Abstract

The purpose of this study was to examine how water movements and carrying distances affect physical exertion, tiredness, and trunk movements of elderly females carrying 3-liters of water in water bags with different capacities on their backs. The participants were 15 early elderly females (median age 71, range 67-74). The cardio vascular responses and the trunk movements of four different carrying conditions were measured for the distance of 500 meters in an indoor hallway. Three of the four conditions were carrying 3 liters of water in bags with different capacities (3-liter, 6-liter, and 10-liter), and the fourth condition was carrying nothing. The average carrying speed for all conditions turned out to be 1.4 meters/second and the ratings of perceived exertion on the Borg scale was 11 (fairly light). However, the relative heart rates varied from 77.1 to 80.3 (%HRmax), which we considered to be a little intense. For the 10-liter water bag, the trunk movements from the starting point to the 35-meter point was significantly less than the other water bags ($p<0.05$). What affected the physical exertion and the tiredness was the carrying distance. It was clear that the differences in capacity of water bags affect the trunk balances right after people start walking.

1. Introduction

In the recent years in Japan, the number of flooded rivers and storms has been increasing due to record-breaking torrential rains, and the number of long water outage has been increasing due to damages on water providing facilities and electricity providing facilities [1,2].

When water outages happen, households are required to use stockpiled water or to obtain water from emergency water supply stations. A manual called “Disaster Preparedness” (Preparing for Disasters) [3,4], which has many versions and is distributed by the local governments, encourages each household to reserve 3 liters of water per person per day for at least three days of worth. Reserving emergency water bags (hereinafter referred to as ‘water bags’) to carry drinking water from the supply stations is also encouraged, but the specifications of the bags, such as shapes, capacities, and carrying method (i.e. on one’s back or with hands) [5] are not included in the manual. In general, the capacities of emergency water bags are between 3 liters and 10 liters. When the water bags are not filled completely, the water moves back and forth in the water bags, and it might affect the walking balance during carrying and might cause fatigue.

Currently, the population of elderly people in Japan is 29.0% [6] and if there is a water outage, they would be responsible to obtain the water on their own because many of them do not live with younger people. If they carry water many times, the accumulation of fatigue and strain on bone joints would be increased. Elderly people need to be aware of their physical strength and reserve water bags that match their physical strength so that they can avoid the fatigue that comes from carrying water.

The purpose of this study was to clearly see the effects of the water movements inside water bags on tiredness, physical exertion, and trunk movements. Water bags with different capacities were used because the water bags that match people's carrying strength might not be available in case of disasters.

2. Participants and Methods

We mailed and also verbally explained the purpose and the contents of the study to 33 early elderly females, who had registered for our health promoting classes for frailty prevention and also had participated in our study previously [7] and obtained consents from 31 of them to be the participants. The reason why we chose females to be the participants was because the average life expectancy of females in Japan is becoming longer than that of males. The exclusion criterions of the participants were set as the following: Those who had limitations on the amount of exercise by their physicians, those who failed to take prescribed medications in the past, those who were taking medicines that affect their heart rates, and those who had any history of cardiac diseases or diabetes. For this study, the required sample size was 10 people (effect size f = 0.4, significance level 5%, power 80%) but we randomly chose and asked 16 people to be the participant in case some of them cancel to be the participants. We were going to use all 16 people as participants since none of them canceled but one of them had to leave for a personal reason after the body measurements were taken, so the remaining 15 people were used for the study.

We set four different conditions to be measured in this study. Three of them were carrying 3 liters of water in a different capacity water bags (3-liter, 6-liter and 10-liter) on the participant's backs and the fourth condition was carrying nothing on their backs.

The health conditions and each study measurements of the participants were recorded by a physical therapist with the Registered Instructor of Cardiac Rehabilitation from June 19 to July 29, 2019. All the measurements of one participant were taken on the same day with enough time to rest.

For this study, "interview", "blood pressure", "heart rate", and "electrocardiogram (ECG)" were set as the items to check participants' health conditions before the actual carrying/walking activities. "Height", "weight", "BMI", "grip strength", and "normal speed to walk 10m" were set as the attribute variables. "Carrying speed" and "ratings of perceived exertion" were used to calculate the degrees of tiredness. "Heart rate" and "blood pressure" were set as the physical exhaustion. "Trunk movement" was set as the indicator for the effect of water movements inside the water bags on trunk movements.

Before the participants carried the water bags, their health conditions were checked, and their heights, weights, grip strengths, and the time to walk 10 meters normally were measured. Blood pressures and the ECGs were measured by using a wireless ECG machine with blood pressure monitor (Balaton EC-12RS, Goodcare Co., Ltd.) and the blood pressure was measured on the non-dominant hand. The grip strength was measured twice on both hands by using a grip strength meter (Hydraulic Hand Dynamometer SH5001, SAKAI Medical Co., Ltd.) in the standing position with the elbow joint flexed to 90 degrees and the highest result was selected to be recorded. The 10 meters-normal-walking-time was measured twice and the faster walking time was selected to be recorded.

The water bags carried by the participants were prepared by filling 3 liters of water using measuring cups. The water bags had three different capacities (3-liter, 6-liter, and 10-liter) so 3 liters of water was 100%, 50%, and around 30% of the water bags respectively. The water bags were positioned on the backs of the participants so that the bottom of the water bags was aligned with the participant's Jacoby's line, which is a horizontal line drawn across the highest points of both of the iliac crests.

The 6-liter water bags and the 10-liter water bags used in this study were purchased from the same company, but they were not making 3-liter water bags, so the 3-liter water bags used in this study were purchased from another company.

The participants carried the water bags for 35 meters in a straight, air-conditioned indoor hallway. The participants were instructed to rest by sitting down for five minutes at the starting point, make 14 round trips of walking 35 meters on the straight hallway, and to walk 10 meters after the final round trip to make the total distance 500 meters [8-10]. The following instructions were given to the participants while they were sitting at the starting point: "Please carry the water bags while imagining that you are carrying them to your home, which is 500 meters away from a water supply station. In case you get tired, you may reduce your carrying speed or rest on the spot." Participants were instructed to wear comfortable clothes and shoes that were easy to move in.

The carrying time was measured every 35 meters. The heart rate and the ECG were continually measured from when the participants were resting at the starting point until they finished carrying and their heart rates were back to the normal level at rest. The blood pressure was measured immediately before the participant started to carry the bags and also at the 455-meter point. The ratings of perceived exertion were checked by using the Borg scale. The participants were asked to report their levels of tiredness (central fatigue and peripheral fatigue) before they started carrying the water bags and at the 455-meter point. (We wanted them to focus on carrying the water bags, so we asked them to report the level of their tiredness that they felt at 455-meter point after they finished carrying the water bags.)

The trajectory lengths of the trunk movements were measured by using a two-point walking movement measuring device (The Walking MVP-WS2-S, MicroStone, Japan). The trajectory lengths of the trunk movements were recorded at the distances from the starting point to 35-meter point, and every 140 meters after the 35-meter point. Triaxle accelerometers were attached to the backs of the participants at the sixth thoracic vertebra (chest sensor) and at the second sacral vertebrae (sacrum sensor). The upper trunk movements were measured by the chest sensor, and the lower trunk movements were measured by a sacrum sensor.

The carrying speed (meters/second) and the relative heart rate (%HRmax) were calculated at the starting point, at the 35-meter point, and at every 140-meter point onward. The relative heart rates were calculated by using the ratios between the predicted maximum heart rates (calculated by subtracting age from 220) and the actual measured heart rates (beat/minute) at each measuring points. The value of the trajectory length of the trunk movements (in milli-meters) calculated from the automatic analysis based on the trajectory in three steps were adopted.

For the statistical analysis, the effects of carrying conditions and walking distances on carrying speeds, relative heart rates, and trunk movements were examined by using two-way repeated measures analysis of variance. When there was a clear effect but not a interaction between carrying conditions and carrying distances, Tukey's honestly significant difference test was used from that point on. In addition, the Dunnet's test was used to see if there were any differences in the carrying speeds, the relative heart rates, and the trunk movements between the 455-meter point and the other locations. The blood pressures (systolic blood pressure and diastolic blood pressure) of each carrying conditions before carrying and at the 455-meter point were examined by using the paired t -test. The comparisons of the differences in systolic blood pressures and diastolic blood pressures affected by each carrying conditions at the 455-meter point were examined using one-way analysis of variance. The comparisons of the ratings of perceived exertion before carrying (at the 0-meter point) and at the 455-meter point were examined using the paired t-test. One-way analysis of variance was used to examine the ratings of perceived exertion for each carrying conditions at 455-meter point.

The significance level of $p < 0.05$ was chosen. SPSS 24.0 for windows was used for statistical analysis.

The study took place under the approval of Tokyo University of Technology ethics committee (Approval Number: E18HS-019).

3. Results

3.1. The Attributes of the Participants.

The median age of the participants was 71 years old, and their average BMI was 22.0 kg/m^2. Their normal walking speed for 10 meters was 1.6 m/s (Table 1).

Table 1. The Attributes of The Participants (n = 15)

Attributes	Mean ± SD
Median Age (range)	71 (67 - 74) years old
Height	151.9 ± 4.1 cm
Weight	50.4 ± 4.1 kg
BMI	22.0 ± 1.9 kg/m^2
Grip Strength	22.0 ± 4.0 kg
Walking Speed	1.6 ± 0.2 m/s

BMI: Body Mass Index.
Walking Speed: Normal speed to walk 10 meters.
Height, Weight, BMI, Grip Strength, and Walking Speed are expressed in mean with the standard deviations.

3.2. The Relationship Between the Carrying Conditions (Amount of Water and Its Moving Space) and the Carrying Speed.

Figure 1 shows the relationship between the carrying conditions and the carrying speeds. There were no interactions ($F (2.1, 22.6) = 0.92$, $MSE = 0.08$, $p > 0.05$) between the carrying conditions and the carrying distances (Figure 1).

Since there was a main effect from the carrying distances ($F (3.1, 34.1) = 930.8$, $MSE = 0.03$, $p < 0.05$), the carrying speeds at the 455-meter point were compared to the carrying speeds at other locations, and there were no significant differences in the carrying speeds under all carrying conditions ($p > 0.05$) and the carrying speeds were constant after the 35-meter point (Figure 1).

There was no main effect from carrying conditions ($F (2.0, 22.2) = 2.1$, $MSE = 0.03$, $p > 0.05$), and the (average of the) carrying speed at the 455-meter point was 1.4±0.1 m/s under all carrying conditions (Figure 1).

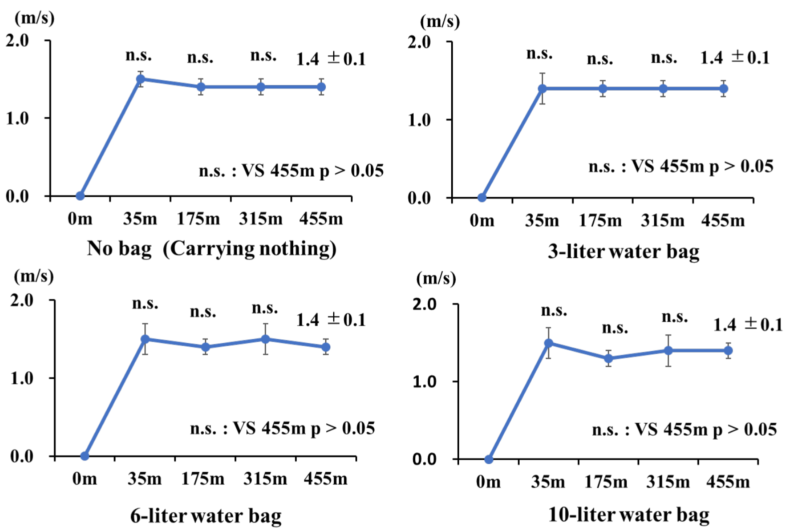


Fig. 1. Carrying Speeds at Each Location (n = 15).
The numbers are the averages of the participants.

3.3. The Relationship Between Carrying Conditions and the Ratings of Perceived Exertion.

Table 2 shows the relationship between carrying conditions and the ratings of perceived exertion (central fatigue and peripheral fatigue) at the 0-meter point and at the 455-meter point.

The median value of the central fatigue at the 0-meter point was 9 (very light) on the Borg scale under all carrying conditions and the median value increased to

11 (fairly light) at the 455-meter point, which indicated that it was a significant increase in the central fatigue ($p < 0.05$).

The median value of the peripheral fatigue at the 0-meter point was 10 (between very light and fairly light) on the Borg scale for the condition of carrying nothing and 9 (very light) for all the other conditions. At the 455-meter point, the median value for carrying the 10-liter water bag was 12 (between fairly light and somewhat hard) and it was 11 (fairly light) for other carrying conditions, so carrying the water bags caused an increase in peripheral fatigue ($p < 0.05$).

The carrying conditions had no main effect on the central fatigue or the peripheral fatigue at the 455-meter point as shown on Table 3.

Table 2. The Relationship between The Carrying Conditions and The Ratings of Perceived Exertion (Central and Peripheral fatigue) at the 0-meter Point and at the 455-meter Point. (n = 15)

	Conditions (water bag capacities)	Carrying distance 0 m	455 m	p value
Central fatigue (Borg scale)	No bag (Carrying nothing)	9 (6-11)	11 (7-13)*	0.004
	3-liter water bag	9 (6-12)	11 (7-13)*	0.001
	6-liter water bag	9 (6-12)	11 (7-13)*	0.000
	10-liter water bag	9 (6-13)	11 (7-13)*	0.001
Peripheral fatigue (Borg scale)	No bag (Carrying nothing)	10 (6-12)	11 (7-13)*	0.006
	3-liter water bag	9 (6-11)	11 (7-13)*	0.002
	6-liter water bag	9 (6-12)	11 (7-13)*	0.001
	10-liter water bag	9 (6-15)	12 (7-13)*	0.006

Central fatigue: Subjective feeling of shortness of breath caused by exercising
Peripheral fatigue: Subjective feeling of limb fatigue caused by exercising
The numbers for the fatigues are the medians　(interquartile range) of the participants.
The ratings of perceived exertion were higher at the 455-meter point compared to before carrying (at the 0-meter point). The fatigues had increased to between 7 (very, very light) and 13 (somewhat hard) with the median of 11 (fairly light) and 12 (between fairly light and somewhat hard).

Table 3. The Analysis of the Variances for the Central Fatigue and the Peripheral Fatigue at the 455-meter Point.

		Sums of squares	Degrees of freedom	Variance estimate	F value	P value
Central fatigue (Borg scale)	Between sample	8.600	3	2.867	0.848	0.474
	Within samples	189.333	56	3.381		
	Total	197.933	59			
Peripheral fatigue (Borg scale)	Between sample	4.717	3	1.572	0.463	0.709
	Within samples	190.133	56	3.395		
	Total	194.850	59			

3.4. The Relationship Between the Carrying Conditions and the Relative Heart Rates.

Figure 2 shows the relationship between the carrying conditions and the relative heart rates at each location in line graphs, and Table 4 shows the data on a chart.

Regarding the relative heart rates, there were no interactions ($F(3.8, 34.5) = 2.3$, $MSE = 29.6$, $p > 0.05$) between the carrying conditions and the carrying distances (Figure 2).

Since there was a main effect from the carrying distances ($F(1.8, 16.5) = 109.6$, $MSE = 110.7$, $p < 0.05$), the relative heart rates at the 455-meter point were compared to the other relative heart rates at each location, and the relative heart rates at the 0-meter point (before carrying) and at the 35-meter point were lower than at the 455-meter point (Table 4). Under all carrying conditions, the relative heart rates after the 175-meter point were not significantly different from the relative heart rates at the 455-meter point (Figure 2).

There was no main effect from the carrying conditions (F (2.9, 25.7) = 0.7, MSE = 58.8, p > 0.05). The relative heart rates at the 455-meter point were between 77.1%HRmax and 80.3%HRmax as shown on Table 4.

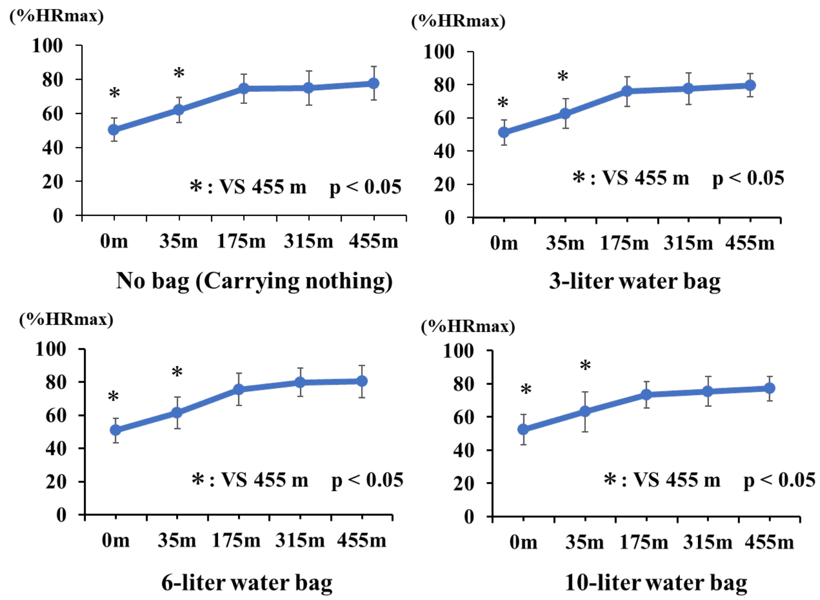


Fig. 2. The Relative Heart Rates at Each Location (n = 15).
The numbers for the heart rate are the averages of the participants. The relative heart rates significantly increased up until the 175-meter point but not after that point on.

Table 4. The Relative Heart Rates at Each Location for Different Carrying Conditions. (n = 15)

	Carrying distance					p value
	0m	35m	175m	315m	455m	
No bag	50.4 ± 6.9	62.0 ± 7.2	74.6 ± 8.6	74.9 ± 9.9	77.7 ± 9.77[ab]	0.000
3L	51.1 ± 7.6	62.5 ± 9.0	75.9 ± 9.0	77.6 ± 9.5	79.6 ± 7.1[ab]	0.000
6L	50.8 ± 7.4	61.3 ± 9.5	75.5 ± 9.8	79.8 ± 8.6	80.3 ± 9.7[ab]	0.000
10L	52.4 ± 9.1	63.1 ± 12.0	73.5 ± 8.0	75.5 ± 8.9	77.1 ± 7.3[ab]	0.000

No bag: Carrying nothing; 3L: 3-liter water bag; 6L: 6-liter water bag; 10L: 10-liter water bag　　p value < 0.05
The relative heart rates are expressed in mean with the standard deviations.
a: compared to the 0-meter point.
b: compared to the 35-meter point.

3.5. The Relationship Between the Carrying Conditions and the Blood Pressures (Systolic and Diastolic).

Table 5 shows the systolic blood pressures and the diastolic blood pressures for each carrying condition at the 0-meter point and at the 455-meter point.

The systolic blood pressures were higher at the 455-meter point under every condition (p < 0.05).

The diastolic blood pressure was not significantly different (p > 0.05) at the 455-meter point compared to before carrying.

There were no significant differences in the systolic and the diastolic blood pressures at the 455-meter point between different carrying conditions (p > 0.05) (Table 6).

Table 5. The Relationship Between the Carrying Conditions and the Blood Pressures (Systolic and Diastolic) at the 0-meter Point (Before Carrying) and at the 455-meter Point (n = 15).

	Condition (Water Bag Capacities)	Carrying Distance 0m	Carrying Distance 455m	p value
Systolic Blood Pressure (mmHg)	No bag (Carrying nothing)	123.5 ± 12.7	156.7 ± 29.3 *	0.001
	3-liter water bag	121.8 ± 13.5	156.3 ± 24.2 *	0.000
	6-liter water bag	125.4 ± 12.5	162.9 ± 29.4 *	0.001
	10-liter water bag	123.1 ± 16.3	151.5 ± 21.5 *	0.000
Diastolic Blood Pressure (mmHg)	No bag (Carrying nothing)	80.9 ± 7.8	80.4 ± 11.2	0.780
	3-liter water bag	82.4 ± 9.6	81.6 ± 14.7	0.738
	6-liter water bag	81.7 ± 10.2	77.7 ± 9.5	0.297
	10-liter water bag	80.0 ± 8.8	78.5 ± 9.7	0.732

* p value < 0.05

The numbers for the blood pressures are the averages of the participants. Only the systolic blood pressures were significantly higher at the 455-meter point than at the 0-meter point.

Table 6. Analysis of the Variances for the Blood Pressures at the 455-meter point.

		Sums of squares	Degrees of freedom	Variance estimate	F value	P value
Systolic Blood Pressure (mmHg)	Between sample	56447.600	3	18815.867	0.179	0.910
	Within samples	5888328.000	56	105148.714		
	Total	5944775.600	59			
Diastolic Blood Pressure (mmHg)	Between sample	55936.850	3	18645.617	0.149	0.930
	Within samples	6995469.333	56	124919.095		
	Total	7051406.183	59			

3.6. The Relationship Between the Carrying Conditions and the Trajectory Lengths of the Trunk Movements on the Sagittal Plane, the Frontal Plane, and the Horizontal Plane at Each Location.

Regarding the upper and the lower trunk movements (measured by the chest/sacrum sensors), there were no significant interactions between the carrying conditions and the carrying distances on all of the planes ($p > 0.05$).

The main effects of the carrying conditions (F (1.7, 11.9) = 4.2, MSE = 1197.7, $p < 0.05$) and the carrying distances (F (3.0, 21.0) = 7.7, MSE = 142.5, $p < 0.05$) were observed only on the horizontal plane (Figure 3). However, regarding the carrying distances, no significant differences were observed ($p > 0.05$) under all carrying conditions when the trajectory lengths of the trunk movements at the 455-meter point were compared to the trajectory lengths of the trunk movements at other locations, and the trajectory lengths of the trunk movements was constant while carrying the water bags (Figure 3).

Regarding the carrying conditions, significant differences in the trajectory lengths of the trunk movements was observed only at the 35-meter point ($p < 0.05$, Table 7). The trajectory lengths of the trunk movements for the 10-liter water bag was 92.8±22.6mm, which was shorter than not carrying anything (111.1±20.9mm), 3-liter water bag (106.0±24.3mm), or 6-liter water bag (98.9±19.4mm) as shown in Figure 4.

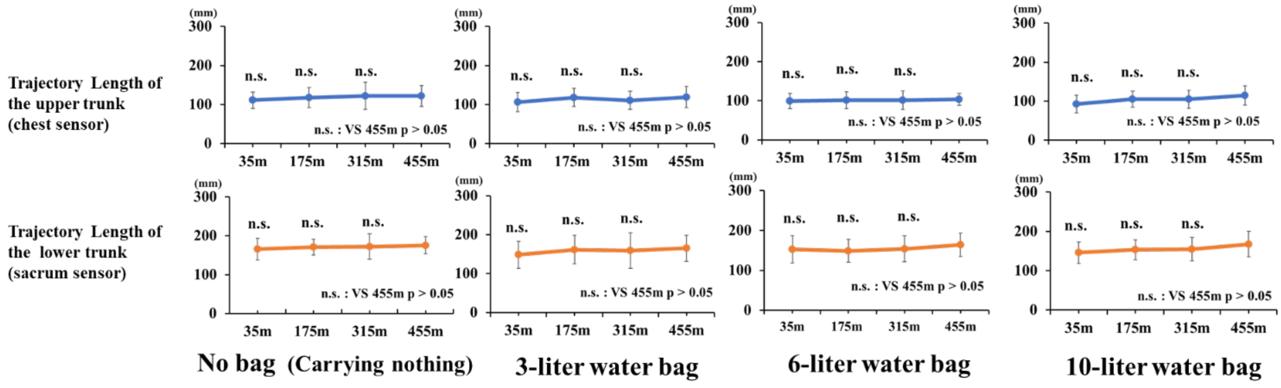
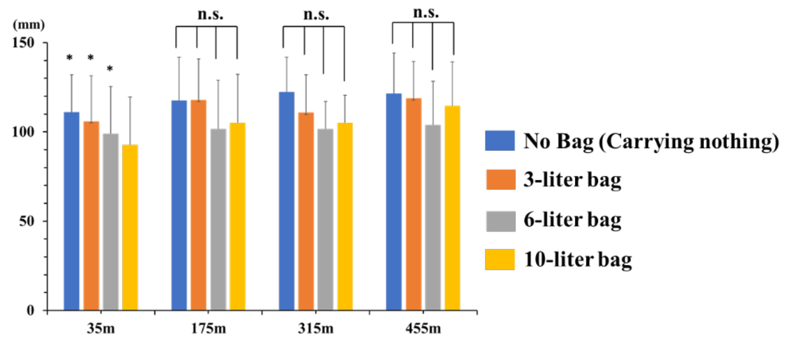


Fig. 3. Movements of the Upper and the Lower Trunk on the Horizontal Plane.
The graphs on the top row (blue lines) show the trajectory lengths of the upper trunk movements, and the graphs on the bottom row (orange lines) show the trajectory lengths of the lower trunk movements.
The numbers are the averages of the participants. The trunk movements in the upper and lower trunk remained constant regardless of the carrying distances.

Table 7. Analysis of the Variances for the Trajectory Lengths of the Trunk Movements on the Horizontal Plane at the 35-meter Point.

	Sums of squares	Degrees of freedom	Variance estimate	F value	P value
Between sample	26409.834	3	8803.278	13.572	0.000
Within samples	35675.048	55	648.637		
Total	62084.881	58			



Conditions (water bag size)	Carrying distances			
	35m	175m	315m	455m
No bag (Carrying nothing) (mm)	111.1 ± 20.9 *	117.6 ± 25.3	122.4 ± 34.9	121.6 ± 26.6
3-liter bag (mm)	106.0 ± 24.3 *	117.9 ± 23.0	110.8 ± 23.0	118.8 ± 27.3
6-liter bag (mm)	98.9 ± 19.4 *	101.6 ± 21.3	101.5 ± 23.8	103.8 ± 15.4
10-liter bag (mm)	92.8 ± 22.6	105.1 ± 20.6	105.0 ± 23.1	114.5 ± 24.6

The Trajectory Lengths of the Trunk Movements are expressed in mean with the standard deviations.

* VS 10-liter water bag $p < 0.05$

Fig. 4. The Relationship Between the Carrying Conditions and the Trajectory Lengths of the Upper Trunk Movements at Each Location (n = 15).
The numbers are the averages of the participants. There was a significant effect of the carrying conditions on the trunk movements at the 35-meter point, and the values for the 10-liter water bag was much lower than the other bags.

4. Discussion

In this study, early elderly females, whose BMI was regarded as "normal" in Japan, carried 3-liters of water in different size water bags (and carrying nothing as a control), which were set as the "carrying conditions".

We concluded that carrying distances affect cardio respiratory function more than carrying conditions because the carrying conditions did not have main effect on carrying speed, the relative heart rates, the ratings of perceived exertion (central and peripheral fatigue), or the blood pressures while there was main effect from the carrying distances. There was no significant difference between carrying nothing and carrying 3 liters of water probably because 3 liters of water was not heavy enough to feel tired for the participants of this study since many early elderly females in Japan often carry things that are about 3 kilo-grams in daily life, such as groceries.

The carrying distance had main effect on four things: the carrying speed, the ratings of perceived exertion, the relative heart rates, and the blood pressures.

The "normal speed" to walk 10 meters was 1.6 m/s but the carrying speed decreased to 1.4 m/s after 35 meter-point for all carrying conditions. It is likely that the participants walked slower to avoid getting tired.

The ratings of perceived exertions were from 11 (fairly light) to 13 (somewhat hard) on the Borg scale, and those values are considered as the range of cardio exercise (moderate) [11,12], so the ratings of perceived exertions in this study are considered as the same level of tiredness caused by common cardio exercise.

The relative heart rates were from 77.1 to 80.3 (%HRmax), which we considered to be between "a little intense" to "intense", and they were higher than the relative heart rates of cardio exercises (moderate), which are between 50 and 70 (%HRmax) [13].

According to the relative heart rates (%HRmax), the physical exhaustion turned out to be "a little intense" to "intense". However, according to the ratings of perceived exertion, it turned out to be in the range of 11 (fairly light) to 13 (somewhat hard) on the Borg scale, which are considered as "cardio exercise (moderate)" [11,12]. The reason for the different outcome is possibly because we chose the participants that exercise regularly, so it was likely that the participants were not able to be aware of exertions even when they are a little over "moderate".

The carrying distances increased the blood pressures significantly. The systolic blood pressures were increased matching with the level of carrying distances that caused sympathetic nerve activities.

The water movement inside the water bag affecting the trunk movements, the trajectory length of the trunk movements measured by the chest sensor (horizontal plane) had decreased significantly from the starting point to the 35-meter point when the participants were carrying the 10-liter water bag. When a 10-liter water bag is filled with 3 liters of water, the amount of water inside the bag is about 30% of the capacity and there are more spaces for the water to move around compared to 3-liter or 6-liter water bags.

We concluded that the participants unconsciously used their upper trunk to stabilize the movements of the water inside the water bags right after they started walking because people's arms and upper limbs move when they walk, and the upper trunk and the lower trunk, which are circular and in the opposite directions, are used to match the swinging of upper limbs and the arms.

There is a possibility that the trunk movement does not get affected by water bags when the bags are filled with more than 50% of their capacities.

Based on the results of the study, when early elderly females prepare water bags for disasters, it will be important to check the distance from their homes to the water supply stations and to have the water bags with appropriate capacities that they plan to carry with full of water. There is a possibility that the weight of the water bags affects the carrying speed and there is also a possibility for the carrying speed to get slower [14] and the number of rests will be increased as the weight increases. "Disaster Preparedness" (Preparing for Disasters) should include the information on the capacities of water bags with full of water that matches the people's strength and carrying distances. It is very important to be careful because the more people get old and weak, the more tiredness and physical exhaustion could be. It would help elderly people to prepare water bags that match their strength and to manage their tiredness that comes with carrying the water bags.

5. Limitations of the study

There was a limitation on this study because our participants included only early elderly females that regularly exercise. There is a possibility for the physical exertion to be more severe for elderly people that do not regularly exercise.

6. Funding

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Abstract (Japanese)

本研究は女性前期高齢者が，災害時に 1 日に必要とされる水 3 リットル/日を容量が違う非常用給水袋（以下，給水袋）に注水して運搬する時の給水袋内の水の揺れと運搬距離が，疲労と身体消耗，体幹動揺軌跡長に及ぼす影響を明らかにすることを目的にした．対象は女性前期高齢者 15 名，年齢は 71(67-74) 歳であった．給水袋の運搬は 4 条件を設定して室内廊下合計 500m の距離を運搬した．給水袋の条件は，4 条件中の 3 条件は 3 リットルの水を容量が違う給水袋（3 リットル，6 リットル，10 リットル)に注水して背負って運搬する条件とした．4 条件目は何も背負わずに運搬した．測定項目は疲労を捉える指標として運搬速度と主観的運動強度を設定し，身体消耗を捉える指標として相対的心拍数と血圧を設定した．給水袋内の水の揺れが体幹動揺に及ぼす影響は体幹動揺軌跡長を設定して測定した．すべての条件の平均運搬速度は 1.4 m/s であり，そのときの主観的運動強度は Borg scale11：「楽である」，相対的心拍数は 77.1 から 80.3 (%HRmax)：「ややきつい」であった．10 リットルの給水袋では運搬開始から 35m までの体幹動揺軌跡長は有意に他の容量の給水袋よりも低値であった（p<0.05)．3L の水運搬では疲労や身体的消耗は水の重量や給水袋の容量の違いが影響しているのではなく運搬距離が影響していた．給水袋の容量の違いと水量の関係は歩き始めの体幹バランスに影響することが明らかになった．

Key words (Japanese)：非常用給水袋，水の量，身体的疲労，災害

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major publications

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