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WAYS OF INCREASING MUSCULAR ACTIVITY
BY MEANS OF ISOMETRIC MUSCULAR EXERTION

A. V. Kovalik

Translation of "Puti povysheniya myshechnoy aktivnosti metodom
beznagruzochnogo napryazheniya myshts," Teoriya i Praktika
Fizicheskoy Kultury, No. 12, Dec. 1979, pp. 38-40.

(NASA-TM-76307) WAYS OF INCREASING MUSCULAR
ACTIVITY BY MEANS OF ISOMETRIC MUSCULAR
EXERTION (National Aeronautics and Space
Administration) 9 p HC A02/MF A01 CSCL 06P

N81-16723

Unclas
14045
G5/52



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546
August 1980

1. Report No. NASA TM-76307	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle WAYS OF INCREASING MUSCULAR ACTIVITY BY MEANS OF ISOMETRIC MUSCULAR EXERTION		5. Report Date August 1980	
		6. Performing Organization Code	
7. Author(s) A. V. Kovalik, Master of Pedagogical Sciences, USSR Master of Sport, Penza Factory-Higher Technical Institute		8. Performing Organization Report No.	
		10. Work Unit No.	
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No. NASW-3199	
		13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration, Washington, D.C. 20546		14. Sponsoring Agency Code	
15. Supplementary Notes Translation of "Puti povysheniya myshechnoy aktivnosti metodom beznagruzochnogo napryazheniya myshts," Teoriya i Praktika Fizicheskoy Kultury, No. 12, Dec. 1979, pp. 38-40.			
16. Abstract The effect of isometric muscular exertion on the human body was investigated by having subjects perform basic movements in a sitting position, in the conventional manner and with additional muscle tension at 50% maximum force and at maximum force, and measuring the pulse, arterial pressure, skin temperature, respiratory rate, minute respiratory volume and electrical activity of the muscles involved. Performance of the exercises with maximum muscular exertion for 20 sec and without movement resulted in the greatest shifts in these indices; in the conventional manner--did not cause substantial changes; and with isometric muscular exertion with 50% maximum force, with and without movement,--resulted in optimal functional shifts. The latter is recommended for use in industrial exercises for the prevention of hypodynamia. Ten exercises are suggested.			
17. Key Words (Selected by Author(s))		18. Distribution Statement This copyrighted Soviet work is reproduced and sold by NTIS under license from VAAP, the Soviet copyright agency. No further copying is permitted without permission from VAAP.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 7	22.

WAYS OF INCREASING MUSCULAR ACTIVITY
BY MEANS OF ISOMETRIC MUSCULAR EXERTION

A. V. Kovalik

Master of Pedagogical Sciences, USSR Master of Sport
Penza Factory-Higher Technical Institute

Physical exercises are recommended for the prevention of hypo-
dynamia in industrial conditions, but their performance in the conven-
tional manner requires certain conditions and is a distraction from
working operations. Meanwhile, it is known that a person can by voli-
tional effort produce additional muscle tension at any time, in any
conditions and in any body position, with movement or without it. In-
vestigations have shown that by the method of isometric muscular exer-
tion it is possible, without leaving one's work place and without in-
terrupting labor operations, to activate various muscle groups with
no negative effect on the nature of the actions being performed [2].
At the same time the absence of data on the effect of isometric muscular
exertion on the human body complicates the development, planning and
practical use of such exercises.

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The present study was conducted to determine the effect of iso-
metric muscular exertion on the human body. In the first series the
exercises included movements that are most frequently encountered in
the process of active life, that are easily done and that involve basic
muscle groups: flexion and extension of the elbows, knees and ankles,
and raising and lowering of the shoulders. The movements were per-
formed with one and two extremities in a sitting position, in the con-
ventional manner and with additional muscular tension, at first with
a force of 50% of the maximum, and then with the maximum 5 and 10 times
(movement cycle--2 sec).

On the basis of the fact that by volitional effort it is possible
to produce and sustain muscle tension even without movement and that
in industrial conditions this form of increasing muscular activity is

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*Numbers in the margin indicate pagination in the foreign text.

the most rational (for the purpose of preventing hypodynamia), in the next experiment exertion of the same muscles was produced and sustained, but in isometric conditions. The pulse, arterial pressure, skin temperature, respiratory rate, minute respiratory volume (MRV), and electrical activity (EA) of the biceps and triceps muscles of the shoulder, the femoral quadriceps, the gastrocnemius, the tibia and the trapezoid were recorded. The skin temperature was measured with a TPEI-1 thermometer over the working muscles for 2 minutes. The respiratory rate and the MRV were recorded with the help of an oxy-spirograph (MYETA 1-25B). Analysis of the results indicates that performance of the exercises in the conventional manner by one or two extremities for 10 sec does not cause significant changes in the recorded body systems (with the exception of the muscular EA). In all cases the changes were statistically insignificant. On performance of the exercises for 20 sec the MRV increased by 3.1 l (124%), $p < 0.05$, and the remaining changes were statistically insignificant. Performance of the exercises with additional isometric muscular exertion equal to 50% of the maximum for 10 sec was accompanied by reliable changes in the pulse and the MRV (in all cases $p < 0.05$). On performance of the exercises for 20 sec the pulse sped up by 9.4 beats (113%), the MRV increased by 8.4 l (157%), $p < 0.01$, respiratory rate--by 1.3, systolic pressure increased by 6.1, and diastolic by 0.7 mm Hg (105 and 102%). The greatest skin temperature increase (+0.54°) was observed over the tibial muscle, $p > 0.1$. On performance of the exercises with maximum muscular exertion for 20 sec the greatest shifts of the recorded indices were noted (on the average for all the exercises): the pulse sped up by 12.1 beats, the systolic pressure increased by 7.5 and the diastolic by 1.9 mm Hg, the respiratory rate increased by 0.4, the MRV--by 10.4 l, and the skin temperature over the muscles increased by 0.42-0.58°. Performance of the exercises without movement was accompanied by approximately the same shifts in the recorded indices.

In evaluating the results of this series of experiments in planning to use similar exercises for the prevention of hypodynamia in industrial conditions, it may be stated that the performance of individual short

movements of local character in the conventional manner does not bring about substantial changes in the body systems and can be equated with the reaction caused by the postural tone activity of muscles that provide the minimal level of functional activity of the body systems. The performance of exercises by the method of isometric muscular exertion with force equal to 50% of the maximum, with movement and without movement, is accompanied by an increase in the functional shifts in the body systems and from the viewpoint of dominant inertia it has a significantly more marked aftereffect. The functional shifts with this reach optimal values, which may be considered a positive factor in the prevention of hypodynamia. The performance of exercises with the maximum isometric muscular exertion is accompanied by disruption of individual functions of the organism (trembling of the extremities and the entire body, change in skin color, disruption of the respiratory rhythm, delay and strain) and also by concentration of attention on the way the exercises are performed, and in connection with this it cannot be recommended for use as industrial exercises for the prevention of hypodynamia.

On the basis of the accumulated data we developed a series of exercises of volitional gymnastics to fit the conditions of sitting work.

1. Raise the feet off the floor, tense the muscles, move the feet in various directions.
2. Press the heels against the chair legs and tense the muscles.
3. Straighten the legs at the knees and tense the leg muscles. If conditions do not allow straightening of the legs, grasp the chair legs with the toes of the shoes and tense the muscles.
4. Tensing the muscles of the shoulder girdle, move the shoulders in various directions.
5. Tensing the back muscles, bend.
6. Move the abdomen: forward--inhalation, backward--exhalation.

7. Tense the buttocks muscles and the muscles of the pelvic floor.
8. Tensing the muscles of the trunk, bend and turn in various directions.
9. Tensing the neck muscles, move the head.
10. Tense all the muscles of the body.

After a preliminary trial the first group of subjects performed the series of exercises 1-3 times in a row; each exercise was done for 10 sec with a force 50% of the maximum. Because in industrial conditions with mass performance of the exercises maintenance of dosed muscle exertion with EMG control of their activity is not possible, the second group performed the exercises without an additional control, just with the instruction: "Perform the exercises with muscular exertion that is equal to half the maximum force." For the purpose of a comparison of the indices with the performance of the conventional series of industrial gymnastics [1] in different ways the third group performed it first traditionally and then with isometric muscular exertion equal to 50% of the maximum (time - 1 min 40 sec).

Analysis of the results (Table 1) shows that a single execution of the series is accompanied by changes in the recorded indices, which, having reached certain values, in the next 2-3 repetitions of the series change insignificantly. /40

Performance of the exercises without additional control of the muscular activity by EMG was accompanied by a significant variation in the muscular exertion, although its average value was maintained at the level of 30-40% of the maximum force, which brought a moderate reaction in the organism. On performance of the conventional series in the traditional manner and with isometric muscular exertion (Table 2) sharply expressed differences were detected. Since the most important thing for the prevention of hypodynamia in industrial conditions is increase of the muscular activity of the basic muscular groups to

TABLE 1. Change of indices after performance of a series of exercises with isometric muscular exertion equal to 50% of the maximum ($M \pm m$)

Performance time (min) and number of times	Pulse for 1 min	Arterial pressure (mm Hg)	Respiratory rate for 1 min	Minute respiratory volume, l
Initial data				
1,40-1	69,4 \pm 1,9	114,4 \pm 3,4/69,3 \pm 1,4	13,6 \pm 0,9	14,4 \pm 1,1
3,20-2	86,2 \pm 2,0*	119,2 \pm 3,4/69,8 \pm 1,4	14,2 \pm 0,9	22,8 \pm 1,1*
5,00-3	88,9 \pm 2,0*	119,8 \pm 3,4/69,7 \pm 1,4	13,8 \pm 0,9	25,6 \pm 1,1*
	89,7 \pm 2,0*	119,4 \pm 3,4/69,4 \pm 1,4	13,6 \pm 0,9	28,2 \pm 1,1*

*The differences as compared to the initial data are reliable, $p < 0.01$.

TABLE 2. Change of indices after performance of a series of exercises by the traditional method and with isometric muscular exertion ($M \pm m$)

Method of performance	Pulse for 1 min	Arterial pressure (mm Hg)	Respiratory rate for 1 min	Minute respiratory volume, l
Conventional method	76,7 \pm 2,1	115,2 \pm 3,4/69,6 \pm 1,5	14,7 \pm 1,0	17,9 \pm 1,1
With isometric muscular exertion	89,1 \pm 2,2	128,8 \pm 3,5/70,1 \pm 1,5	17,8 \pm 1,1	32,7 \pm 1,2
Difference, p	+12,4 <0,01	+13,6 <0,05 +0,5 >0,1	+3,1 <0,05	+14,8 <0,01

the level that corresponds to the optimal individual characteristics of the participant, it may be considered that in each concrete case the regimen of volitional gymnastics exercises (their duration, number of repetitions, degree of muscular exertion, etc.) should depend on individual characteristics, labor conditions and living conditions. In the process of such exercises each can establish for himself the optimal regimen that most suits him; his personal sense of well-being will serve as the control in the determination of the time and the intensity of the exercises.

Thus, periodic performance of exercises of volitional gymnastics in the daily routine of those categories of workers whose labor is done in conditions of limited space and little motor activity, in combination with traditional forms of the performance of physical exercises, can significantly increase their effectiveness in the fight against the detrimental effects of hypodynamia.

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