J Y V Ä S K Y L Ä N Y L I O P I S T O N

KANSANTERVEYDEN LAITOKSEN JULKAISUJA

U N I V E R S I T Y O F J Y V Ä S K Y L Ä

DEPARTMENT OF PUBLIC HEALTH PUBLICATIONS

No 15 1972

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Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning

This research has been supported by a grant from the Finnish Research Council for Physical Education and Sports, Ministry of Education, Finland

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URN:ISBN: 978-951-39-9044-2
ISBN 978-951-39-9044-2 (PDF)
ISSN 0357-4563

Jyväskylän yliopisto, 2022

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ABSTRACT

The urinary excretion of noradrenaline and adrenaline, 17-OHCS, the concentration of hemoglobin, hematocrite, the concentration of plasma lactic acid, K^+, Na^+ and blood glucose, in 22 male students were determined both before and after a periodic, submaximal exercise on a bicycle ergometer. The measurements were repeated three times during a nine-week endurance conditioning where eleven of the subjects participated.

Except for the decreased heart rate during exercise ($p < .001$) and increased $\dot{V}_{O_2}$ max. ($p < .001$) the endurance conditioning resulted in a significantly decreased concentration of the average plasma lactic acid in the trained subjects during the most anaerobic phases of exercise ($p < .025$).

During the loading both the noradrenaline and adrenaline increased significantly ($p < .001$) as compared with the situation of relative rest before the exercise. During loading the respective urinary excretion of 17-OHCS did not change significantly. The training did not result in any significant difference between the trained and untrained groups in the urinary excretion of the adrenal hormones and the sympathetic transmitter, noradrenaline.

Beside the increased concentration of plasma lactic acid during the exercise periods ($p < .001$), temporary increases and decreases in the concentrations of blood hemoglobin and hematocrite values were found after the heaviest and lightest anaerobic phases of loading respectively ($p < .05-.001$). After the period of endurance conditioning the trained and untrained groups differed significantly in the response of hemoglobin after the first phases of exercise ($p < .025-.05$). The fluctuation was then found only in the untrained group. No significant difference in hematocrite values due to the conditioning was found.

Since the second loading phase of the exercise period the concentration of K^+ in plasma increased significantly ($p < .05 - .001$). The respective lowered rations of Na^+/K^+

were found ($p < .05 - .001$) but not change in the Na^+ concentrations. No significant effect of conditioning on these ionic concentrations were noted.

catecholamines; 17-hydroxycorticosteroids; hemoglobin; hematocrite; plasma lactic acid; blood glucose; exercise; endurance conditioning

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Introduction

At present a great amount of literature demonstrates that an augmented sympatho-adrenal secretion is followed by an increase in the excretion of noradrenaline and adrenaline due to various stimuli of varying dominance of physical and/or psychic origin as reviewed, for example by Euler (1964), Levi (1967) and Mason (1968 b). A large inter- and intraindividual variation seems to characterize those responses as well as many other complicating factors requiring accurate standardization in experiments (Levi, 1967).

Physical work of even a moderate degree stimulates the sympathoadrenal responses and induces an increased excretion of catecholamines into blood or urine as suggested in many studies even during the first half of this century (cf. Takahashi, 1961). Similar results have been demonstrated since then in numerous studies reviewed by Euler (1969) and confirmed by many others in the laboratory (e.g. Gray and Beetham, 1957; Vendsalu, 1960; Banister, 1966; Lindmar et al., 1968; Conard et al., 1969; Becker and Kreuzer, 1969; De Schaepdrijver and Hebbelink, 1969; Frankenhaeuser et al., 1969; Howley et al., 1970, Sarviharju, 1970; Häggendahl et al., 1970; Raven et al., 1970; Kotchen et al., 1971) and under natural experimental conditions (e.g. Ehringer and Spreitzer, 1967; Vuori and Pekkarinen, 1969).

On the other hand, we do not know as much about the role of good or poor physical condition in the endocrine excretions in a state of muscular strain or during rest and recovery. Adrenal hypertrophy has been produced by an intensive physical training among rats as caused by an increase of both the noradrenaline- and adrenaline-storing parenchyma (Eränkö et al., 1962) and also without any effects on the adrenal weight or its adrenaline content in guinea pigs (Östman and Sjöstrand, 1971). In recent studies when there was no cardiac hypertrophy, a significant reduction in heart catecholamines was noticed after prolonged physical training (DeSchryver et al., 1969), but when it resulted in cardiac hypertrophy, the total noradrenaline and its concentration in the heart increased significantly (Östman and Sjöstrand, 1971). This discrepancy in results and the functional significance of the phenomenon are still obscure.

The previous suggestion that a well-trained individual should be more physically strained than an untrained in order to produce an equal increase in the excretion of catecholamines (Euler and Hellner, 1952) is consistent with some evidence about the decreasing effect of intensive physical training on the urinary excretion of VMA (Adam et al., 1968). An over-all concept can be visualized by which a certain kind of physical training will increase the parasympathetic tone or decrease the sympathetic one during rest (e.g. Raab et al., 1960; Nöcker, 1964).

An organism reacts to the changes in the internal and external environment not only via the hypothalamo-sympathico-adreno-medullary pathway but also via the hypothalamo-hypophyseo-adreno-cortical pathway. According to numerous studies an essential activation of the adrenal cortex is demonstrated to follow after various kinds of mental and/or fairly severe physical strain such as trauma, physical and surgical procedures directed to a human or an animal as reviewed recently by Mason (1968 a). He also reviews several studies suggesting that the most intensive reactions are found both in human beings and in animals in new situations accompanied by some kind of unfamiliarity and threat. The picture about the effect of exercise, especially on adrenocortical activity, is not yet clear, The level of 17-OHCS has increased during excercise in blood (Kägi, 1955; Pace et al., 1956; Crabbe, 1958; Nazar, 1965; Vuori and Pekkarinen, 1969) and in urine (Venning and Kazmin, 1946; Hatch et al., 1956; Hill et al., 1956; Pace et al., 1956; Vuori and Pekkarinen, 1969), and has decreased in plasma (Cornil, 1965), and also after the primary increase during prolonged excercise (Kägi, 1955), or did not alter in plasma (Wegman, 1968, Moncloa et al., 1970) or in urine (Thorn et al., 1953, Hellman et al., 1956). The urinary excretion of ketogenic steroids has not altered, either, during exercise (Connel et al., 1958). Moncloa et al. (1965, 1970) have demonstrated a transient increased plasma concentration and urinary excretion of cortisol under hypoxia during exercise in man and a fall in cortisol concentration during exercise under hypoxia at high altitudes; sea level does not alter the cortisol concentration. Systematic experimental evidence of the relationship of physical condition and the activity of adrenal cortex with its reflections on the levels of hormones in blood and urine are few. Hatch et al. (1956) found a significant negative correlation between the Harward Step-test scores and the urinary excretion rate of 17-OHCS.

Some data suggest a significant hypertrophy of the adrenal glands in animals with a corresponding increase in hormone levels at the beginning of training (Frenkl and Csalay, 1962). Since the onset of the research they found the weight of the adrenals increased continuously when the plasma hormone level decreased below the normal concentrations.

The aim of the present study was to throw light on the effect of regular physical conditioning on the urinary excretion of noradrenaline, adrenaline and 17-hydroxycorticosteroids as well as on the concentration of selected blood parameters during relative rest and muscular work.

SUBJECTS AND METHODS

Subjects

The subjects were sixteen volunteer, healthy, young men. They were matched from two separate groups with regard to their submaximal working heart rate in order to get as homogenous test and control groups as possible. Group A consisting of 5 control subjects and 5 test subjects was matched from 15 students, and group B consisting of 7 control subjects and 7 test subjects from 24 students. One pair from group A was excluded, the control subject because of his high physical condition due to participation in heavy physical work during the training season and one trained subject because a great amount of data concerning him was lost due to technical reasons. Group B included two test Ss as control Ss and two control Ss as test Ss from group A. These two groups are combined in the results section.

Loading procedures

Physical loading was achieved by a bicycle ergometer test consisting of three separate phases (Figure 1.) expressed as pedaling time per work load: (1) 6 minutes/1200 kpm/min, (ergometer work I) + 34 minutes rest in a sitting position + (2) 20 minutes/900 kpm/min, (ergometer work II) + 20 minutes rest in a sitting position + (3) 19 minutes/900 kpm/min, immediately 1 minute/1500 kpm/min, (ergometer work III). The bicycle ergometer test was carried out before the training period and repeated three times at a three week's interval for both groups A and B.

A predominantly mental loading was achieved only for group B with an emotionally loading choice reaction test modified to a more difficult form than in the investigator's previous study (Sarviharju, 1970). The results for this study are published elsewhere (Sarviharju and Mattila, 1972). Before the first measurements, all the subjects had once been in a measurement situation quite similar to the present one. A part of these pretests are to be reported elsewhere (Sarviharju, 1972).

The measurements for group A were performed from June to August and for group B from September to November.

The heart rates were calculated from electrocardiograms at the following steps of the test: (1) the heart rate at relative rest and the recovery heart rates were measured at the beginning of the last minute during rest in a sitting position before starting the pedaling, (2) the heart rate of the first phase of pedaling is the mean of the heart rates at the end of the last two minutes of pedaling; and (3) the heart rates in the second (20 minutes pedaling) and third (19 + 1 minutes pedaling) phases were measured at the end of the last working minute.

Maximal capacity of O_2 uptake was determined by the indirect method devised by Åstrand and Ryhming (1954). The steady state heart rates of the ergometer work I, 6 minutes 1200 kpm/min, were used in this process as well as an extrapolation of the nomogram, if necessary.

Conditioning procedure

The test subjects exercised on a bicycle ergometer five days a week, 30-60 minutes at a time, under the supervision of the research workers. The pedaling time was progressively lenghtened and equally for each subject in the same group during the nine weeks' training period. The work load was increased, individually for each subject, in order to keep the heart rate during the exercise at 160-170 beats/min. All kinds of physical exercise besides the training program were allowed to be practiced by the trained subjects.

The control subjects were not allowed to participate in any physical exercise, but in some cases they were asked to continue their previous habits of moderate physical activity. All the subjects had an exercise diary and their physical activity could roughly be estimated on that basis.

Chemical methods

The blood samples were taken: (1) ten minutes before the startup of the test, (2) five minutes after the cessation of the first phase of pedaling, (3) and (4) five minutes after the cessation of the second and third phases of pedaling, respectively. Blood was collected through disposable needles from an antecubital vein into a test tube containing dried heparine, while the subjects were in a supine position. The urine samples were collected from a period of three hours before and after the work. The second period contained the whole workphase.

From the blood the hemoglobin and hematocrite were determined and the rest of the samples immediately centrifugated for 10 minutes at 3000rpm. Plasma was separated for the determination of free fatty acids (FFA), K^+, Na^+ and lactic acid. The results from plasma FFA are reported elsewhere (Sarviharju and Vihko, 1972).

The precipitation of proteins was done from 0.1 ml of whole blood and the glucose concentration determined by the method of Hultman as modified by Hyvärinen and Nikkilä (1962).

Plasma lactic acid was determined by the enzymatic method with reagents and instructions of CF Boehringer - Soehne GmbH (1967). The intensity was measured with a Beckman DB - spectrophotometer with a wave length of 366 nm for lactic acid, 630 nm for glucose and 540 for hemoglobin.

The concentration of plasma K^+ and Na^+ were determined from proper dilutions of plasma with an EEL - flame photometer and Merck's Titrisol comparison solution.

Free catecholamines in the urine were determined by the fluorimetric method of Euler and Lishajko (1961), by the adsorbtion onto alumina in pH 8.3, eluating with acetid acid and oxidizing with potassium ferricyanide in pH 6.2 to adrenochromes and transforming them into fluorescent trihydroxyindoles with alkalines. The intensity of fluorescence was measured with a Perkin - Elmer MPF-2A fluorescence spectrophotometer with an activation wave length of 396 and 440 nm and an emission wave length of 510 nm.

The total amount of 17-OHCS in the urine was determined by the method of Few (1961) as modified by Thomas (1965). The corticoids were then reduced, first with sodiumborohydride and oxidized with sodiummetaperiodate to 17-ketosteroids. After the hydrolysis the steroids were extracted into dichloretane and washed with Na-ditionite and distilled water. The dichloretane was evaporated and from the residuum the reaction of Zimmerman was taken. The colour intensity was measured with a Beckman DB - spectrophotometer with wave lenghts of 440, 520 and 600 nm. The compound of comparison used was dehydroisoepiandrosterone. The Allen correction coefficient was used.

The methodological error of the double determinations from the data was 9.5 per cent for noradrenaline and 11.7 for adrenaline. The error was 2.9 per cent for 17-OHCS, 1 for K^+, 1.3 for Na^+, 2.5 for glucose and 7.9 for lactic acid.

Standardization of procedures

The order of the collection of specimen and the other procedures are presented in Figure 1. The subjects were not allowed to participate in any physical exercise the day before the tests. The evening before they had to go bed at 10 p.m. From that moment they were forbidden to eat or smoke before the tests were over. This prohibition was supervised by the investigators since the reporting of the subjects at the laboratory at 6 a.m.

In order to bring about an adequate urine output the subjects were to take 300 ml (group A) or 400 ml (group B) of water at the laboratory before and after the exercise period.

The ergometer tests were always carried out between 9-11.50 a.m. Every time all the phases were in the same order and the same pairs were pedaling on the same day. The lengths of the resting periods were dictated only by the practical arrangements of the test. The temperature, humidity and air currents of the laboratory were measured and very similar every time. The light clothing of the subjects was standardized. The test procedures were carried out during the same day per a subject each of the four measurements during the training season.

Statistical analysis

For measuring the effect of the various loadings the results were tested with Student's t-test for correlating means between the rest and loading situations concerned, and only in the measurement before training.

The effect of training was analyzed by the two - way covariance analysis for repeated measurements. The pre-treatment measurements were used as covariates. A logarithmic transformation was performed for the whole data with some improvement in the premises but without an effect on the rate of statistical significance. Only the nontransformed data are presented here.

In some variables the missing data varying from zero to three observations per analysis, i.e., with the maximum of 2.7 per cent, were substituted with the group mean or with the observation of the nearest measurement for the subject concerned with an equivalent reduction of degrees of freedom.

RESULTS

Effect of loading

All the phases of exercise significantly increased ($p < .001$) the concentration of plasma lactic acid when compared to the previous situation of relative rest (TABLE III and IX; Fig. 3). No significant differences in blood glucose were found between the rest before the work and the exercises (TABLE III and X; Fig. 4). Hemoglobin increased after the first phase of muscular work ($p < .05$) and decreased ($p < .01$) again after the second phase of work (TABLE IV, XI; Figure 5). Hematocrite (TABLE IV, XII; Figure 6) behaved similarly but increased significantly again after the third phase of muscular work ($p < .02$ - $.001$).

The concentration of K^+ in plasma (TABLE V and XIII; Fig. 7) increased after all phases of exercise, except the first phase as compared to the relative rest before the work ($p < .05$ - $.001$). The respective average values of the ratio between Na^+ and K^+ (TABLE VI and XV; Figure 9) were lower than in the control situations ($p < .05$ - $.001$).

Before the endurance conditioning the average output of urine (TABLE VII and XVI; Fig. 10) decreased significantly ($p < .01$) during the period which included the exercises as compared to the previous resting period. During the total period of exercise the urinary excretion of both noradrenaline and adrenaline (TABLE VII and XVII-XIX; Figure 11) increased significantly ($p < .001$). The respective ratio of noradrenaline to adrenaline decreased ($p < .01$). No significant differences were found in the urinary excretion of 17-hydroxycorticosteroids between the relative rest and exercise periods.

Effect of conditioning

The heart rates and the predicted maximal capacity of O_2 uptake ($\dot{V}_{O_2}$ max.) are presented in TABLE II and Figure 2.

The summary of the statistical analyses in question appears in TABLE VIII. The average heart rate of the trained subjects was significantly lower ($p < .001$) than that of the control subjects in measurements performed during pedaling and the recovery phases. This effect was already observed after three weeks' training. During relative rest before the pedaling, the average heart rates of the two groups did not differ significantly. The heart rate of the control group decreased significantly ($p < .05$) in the first phase of the ergometer test in measurements after six and nine weeks from the outset of the study.

The average predicted maximal capacity of O_2-uptake increased in the trained group significantly ($p < .001$).

The concentration of lactic acid in plasma (TABLE III and IX; Figure 3) between the trained and nontrained groups differed significantly after training after the work I ($p < .01$) and the work III ($p < .025$). During relative rest and after the work II the groups did not differ significantly. Neither did they differ in any situations in the concentration of blood glucose (TABLE III and X; Figure 4).

After the training the hemoglobin concentration in blood (TABLE IV and XI; Figure 5) was lower in the trained group after the first two phases of ergometric work ($p < .05 - .025$), but not after the third phase nor during the relative rest before the muscular work. No significant differences between the groups were found either in respective hematocrite values (TABLE IV, XII; Fig. 6) nor in the concentrations of K^+, Na^+ in plasma or in the ratio of Na^+ to K^+ (TABLE VI and XIII-XV; Figures 7 - 9).

In the urine output (TABLE VII and XVI; Figure 10) no significant differences were found between the groups after the training. Neither was anything similar found in any situations in the urinary excretion of catecholamines (TABLE VII, XVII-XIX; Figure 11) nor 17-OHCS (TABLE VI and XX; Figure 12). The adrenal excretions did not correlate significantly with the urine output.

DISCUSSION

Effect of loading

Blood variables

The loading phases used were selected to represent roughly the various amounts of the aerobic and anaerobic energy production during work. All of these employed a slight to moderate anaerobic energy production, as can be seen in the concentrations of plasma lactic acid. All the loadings were submaximal in relation to the maximum of approximately 150 mg per cent as stated by Margaria (1963).

On the other hand, the present results with respect to lactic acid do not agree very well with the evidence of Margaria (1963), who states that the maximum is reached at about 5 - 8 minutes after stopping work. The average concentration of lactic acid five minutes after the moderate anaerobic work of six minutes at 1200 kpm/min was only about one half to one quarter of the respective values obtained in a previous study (Sarviharju 1970) only one minute after a very similar kind of six minutes work. The reason for this is uncertain.

Obviously the loadings used were not sufficient to produce a significant decrease in the blood glucose in spite of the fast before and during the experiment. This is consistent with the results of e.g. Young, et al., (1965) who demonstrated only a minor tendency of a decrease in blood glucose in the beginning of prolonged physical work and in resting post-absorptive subjects. Obviously the glucose mobilization during the muscular work neutralized the tendency of the decrease induced by the increased use by peripheral tissues.

The present demonstration of the increased hemoglobin concentration and/or hematocrite after exercise agrees well with the results reported by many authors as reviewed and confirmed by Holmgren, (1956). This increase was previously suggested as resulting from the expulsion of blood from the depots (e.g. Barcroft and Stevens, 1927). At present this is generally interpreted as showing a decrease in the blood volume, probably induced by a passage of the plasma filtrate from the circulating blood to the interstitial space (e.g. Kaltreider and Meneely, 1940; Ebert and Stead, 1941). In the present work this shift seems to be roughly related to the intensity of the exercise, the hemoglobin concentration and hematocrite fluctuating according to the varying anaerobic pattern of the loading phase.

In spite of the five minutes latency before the collection of blood samples after the exercise an increase in plasma-K^+ was found, when the Ss were recovering from the second phase of pedalling. This is consistent with some previous evidence regarding the increased concentration of K^+ in plasma due to muscular loading of even short duration (DeLanne et al., 1959; Kilburn, 1966; Metivier, 1969). Some authors suggest that the increase of K^+ is related to the amount of work done during repeated muscular work (Grob et al., 1957). They suggest that the organic phosphate compounds exist as K^+ salts in cells and that the release of K^+ during exercise is produced by their phosphorylation and glycolysis. It has been suggested that the increase in permeability known to result from depolarization of the muscle membrane (Fatt, 1954) results from the hypoxic state of the muscles due to the excretion of catecholamines (Highman et al., 1959). According to the postulation of Kilburn (1966), exercise produces acidosis in the muscle cells, some K^+ is exchanged for H-ions and both are released from striated muscles. He states that this is the finding most consistent with the increased H-ion concentration of arterial blood during moderate systemic exercise and in blood draining from the exercising forearm. However, it was suggested that in view of the small fraction of change in muscle K^+ required to produce a large increase in extracellular K^+, some other mechanisms may explain the liberation of K^+ into venous blood during exercise. Possibly the increased permeability and the increase produced in the electrolyte concentration in plasma could be interpreted as a mechanism of protection necessary to maintain the blood osmolality and plasma volume, as stated by Metivier (1969). This effect of exercise was not previously found in our laboratory (Sarviharju, 1970), where six minutes of pedalling work was possibly even more anaerobic. Because there was no reason to believe in any latency in the increase of K^+ in plasma, the possible explanation for the inconsistency would be the relatively great lability of this electrolyte in plasma which may also be due to various factors other than exercise or any other kind of loading. The permanence of the plasma Na^+ is similar to the previous data, which indicates that this concentration is quite stable (e.g. Schönholzer, 1959; DeLanne et al., 1959; Aurell et al., 1967).

Endocrine variables

The present results indicate a significant increase in the noradrenaline excretion after muscular work. This kind of increase has been considered a part of the cardiovascular-response system regulating reactions in muscular work, while the mechanism responsible for the increased adrenaline output is not clear (Euler, 1967). Frankenhaeuser et al., (1965, 1967) state a consistent relationship between the amount of adrenaline release and the degree of mental stress or unpleasantness and consider the adrenaline increase likely to be at least partly associated with the subjective emotional reaction accompanying heavy physical work rather than to be elicited by the work itself (Frankenhaeuser et al., 1969).

The results of 17-OHCS could possibly be considered to agree with the previous evidence cited in the present review of literature. Consequently the first increase in the concentration of steroids in plasma after the outset of muscular work would be followed by a decrease due to the increased peripheral utilization of adrenal cortical hormone (Kägi, 1955; Hill et al., 1956). This increased utilization would possibly be met by a corresponding increased secretion from the adrenal cortex. Consequently, in the present study it was possibly measured during a phase, when the utilization process was reflected in the decrease in urinary 17-OHCS, however, due to the methods of measurement, a significantly decreased level of 17-OHCS was not yet found. This would be due to the fact that the work time was not followed by any prolonged hypoxia, which according to the demonstrated amount will produce a transient increase in plasma concentration and urinary excretion of cortisol (Moncloa et al., 1965, 1970).

To summarize the loading effects on the urinary excretions of both catecholamines and 17-OHCS one may well suggest a consistency with the idea that the difference in steroid response to physical exercise and emotional loading on the one hand (Connell et al., 1958) and the affective states of differing quality on the other (Curtiss et al., 1960), does not agree with the nonspecificity in Selye's sense (1950). This is especially true if one relates them to the balance between hormones rather than to some single hormone alone.

Effect of endurance conditioning

Physical performance

The endurance conditioning can be considered effective; a rise in physical fitness in the trained group was obviously achieved as was shown by a statistically significant decrease in the heart rate during steady state at work and an increase in the predicted $\dot{V}O_2$ max. even after three weeks training. The heart rate during relative rest is obviously not sensitive enough to show in every case the effect of prolonged physical training of relatively high degree and short duration as used in the present study.

Also in the control group the submaximal heart rate during work decreased almost significantly after ergometer work I in measurements after six and nine weeks from the outset of the study. A possible reason for this cannot be the increased physical activity, if the crude approximation of the physical activity of the control subjects is valid on the basis of their exercise diaries. I suppose that some kind of adaptation to or "learning" of the experimental loading procedure has a central role in the understanding of this curious "training effect". This kind of improvement in the physiological state at a constant level of performance can indicate, it is suggested, either the physiological adjustment to training or the psychological adjustment to habituation (Glaser and Griffin, 1962). Direct measurements of oxygen consuption during loading might reveal more accurately the "true effect" of conditioning on the physical performance and eliminate the effects of adaptation to the situation.

Blood variables

The produced effect of training is shown even by the observation of the significant difference between the groups in the plasma lactic acid after the most anaerobic phases of muscular work after the training. This kind of a lower concentration of the lactic acid in the more conditioned subjects during the same level of exercise is suggested by many authors, e.g. by Crescitelli and Taylor (1944), the training is also known to result in an increased capacity for accumulating lactic acid due to a greater utilization of anaerobic energy reserves as suggested, for example, by Knehr et al., (1942).

The present intensities of exercise as related to the work time obviously were not sufficient to produce any pronounced loading on the glucose mobilization to facilitate the differentiation of the trained and untrained groups.

After the training the trained group does not seem to respond to exercise with such a prominent increase in the hemoglobin concentration and hematocrite as the control group. There seems to be a logical explanation to this change due to the endurance conditioning. It has been suggested that the increase in the hemoglobin concentration is a compensatory function for the reduced oxygen saturation of the arterial blood necessary to increase the oxygen transport capacity (Kjellberg et al., 1949; Holmgren, 1956). Consequently the increased circulatory capacity of the trained subjects will result in a less pronounced need to mobilize that compensatory mechanism during an exercise of the same level of intensity. Some previous observations of plasma K^+ and Na^+ tended to show a possibility that the trained subjects would react at least to a short and intensive physical loading with more increased concentrations of plasma K^+ and with a lowered ratio of Na^+ to K^+ and Na^+ than would the untrained subjects (Sarviharju, 1970). These results were not confirmed by the present results. Some previous evidence suggest that the physical training will increase the internal K^+ in skeletal muscle cells during rest and the capability to empty these stores when exposed to exercise and thereafter to result in an increased exchange of K^+ and Na^+ in the cells (Nöcker, 1964). Consequently it would be more probable during the same level of exercise to find a lower concentration of K^+ in plasma in the trained subjects than in the untrained ones due to the possibly greater efficiency in muscle work. The over-all greater lability and the result of no significant differencies between the trained and untrained subjects in the present study does not support the idea of some kind of greater sensitivity in the trained subjects to emptying the K^+ stores during exercise.

Endocrine variables

Beside the methodological errors in the determination, some other uncontrolled factors might probably have had an effect especially on to the level of hormone excretions. Such hormone diurnal and seasonal rhythmicity is known to be relevant with reference to catecholamines (e.g. Hale et al., 1966; Johansson et al., 1969) and 17-OHCS (e.g. Bartter et al., 1962). The rhythmicity does not necessarily follow a 24 hour periodicity as suggested by Orth et al. (1967). This makes it possible that the present aim to control the diurnal fluctuation by performing the measurements at the same time of the day through the whole period of experiment will not suffice to eliminate the error due to rhythmicity. Lack of sufficient data makes it impossible to evaluate this effect. No evidence was found to support the hypothesis of a decreased sympatho-adrenal activity due to endurance conditioning. Some previous evidence refers to a decreased adrenaline excretion in situations of relative rest, for example, in the forenoons of the control days (Sarviharju et al., 1971), and in the afternoon (Sarviharju, 1970), but not in actual stress situations, i.e. during flights (Sarviharju et al., 1971), CRT-competition (Sarviharju and Hattila, 1972), during exercise (Sarviharju, 1970; 1972), or not even in the afternoons of control days (Sarviharju et al., 1971). This would suggest that the effect probably manifests itself at full rest, for example in sleep, and yet does not extend even to a low level of strain such as in light daily work. Training of much greater intensity and continuity than the kind used in present studies might be needed to extend the effect to cover the reactions of catecholamine excretion during some physically and/or mentally more loading conditions.

The previous data concerning noradrenaline excretion are even contradictory to the hypothesis, because a more increased excretion of noradrenaline was found in the trained subjects in the afternoon of a control day (Sarviharju et al., 1971) and in the respective forenoon (Sarviharju, 1970) with no significant difference between the groups during physical or mental loadings. Because of the well-known effect and a relative specificity of physical loading on this excretion, it could have been expected in particular that endurance conditioning would induce a decrease in the loading of the sympathetic nervous system at the same level of physical work. Because of the inconsistency in the results of the first studies and of the lack of significant differences in catecholamine excretions in the present study the suggestions presented will remain quite hypothetical.

There are some points of view to be considered as factors possibly masking the effect of training on the endogenous excretion of catecholamines reflected in the urinary excretion. Wurtman (1965) suggests that the fraction of the active material of catecholamines metabolized of rebound before its excretion does not necessarily remain constant, when there is a change in its rate of release. Furthermore there is an inconsistancy in previous studies as a whole, as to the relationship between the urine output and the excretion of catecholamines. Insignificant correlation between these functions was found to be consistent with some previous data (e.g. Bloom et al., 1963; Levi, 1963; Graham et al., 1967) and not with some others (De Schaepdryver and Leroy, 1961; Dawson and Bone, 1963; Hathaway et al., 1969).

Evidence has also been presented stating that the noradrenaline excreted in the urine is solely derived from the catecholamines in circulating blood, that its clearance is not affected by changes in urine pH or flow, and that a partial reabsorbance of about 40 per cent from the glomerular filtrate (Overy et al., 1967). However, this mechanism of reabsorbance was not identified with certainty since the possibility of metabolic degradation by means of catechol-o-methyl transferase or by conjugation was not excluded. The investigator feels that anyway this evidence suggests the possibility of intervening mechanisms which could change the sensitivity of the direct measurement of urinary noradrenaline as a generally acceptable indicator of sympathetic activity. The change would be in rebound, degradation and reabsorbtion mechanisms due to chronic exposure to intensive physical activity.

Hatch et al., (1956) suggest that the plasma flow and filtration rate are closer to normal in subjects, who could increase the minute volume more effectively than do those in good physical fitness. Despite data concerned with the positive correlation of infused catecholamines and their urinary excretion under normal conditions (e.g. Elmadjian et al., 1958) we cannot exclude the possibility of producing in a relatively more decreased urinary excretion of catecholamines in the nontrained subjects than in trained ones in a case of possibly more increased excretion into the blood in nontrained subjects under the same physical work load.

After the conditioning no significant differences between the groups were found in the urinary excretion of 17-hydroxy-corticosteroids. The over-all variations and renal functions discussed in connection catecholamines in this text may be valid even in this case. One can suggest the excretion of 17-hydroxycorticosteroids to be a resultant of many factors such as the secretion, peripheral utilization and excretory functions. Since we do not have explainable systematic data about these function profiles during muscular work of varying degrees of intensity and duration, the present method of collection seems to be crude and holds quite insufficient promise to be valid in the present kind of use in the evaluation of the 17-hydroxycorticosteroids response in exercise.

Acknowledgement

This study was done with the assistance of a 1969 research grant from The Finnish Research Council for Physical Education and Sports, Ministry of Education. Thanks are due to Professor Jeddi Hasan, the Director of the Department of Public Health, University of Jyväskylä, Finland, for his support and advise and due to LuK Veikko Vihko, LiK Erkki Mattila, LiK Olli Manninen, yo Satu Hannula, yo Liisa Kemppinen, yo Kirsti Vaarna (chemical determinations), FM Liisa Havola-Pitkänen and Miss Patricia Baker (English revision) and also due to many others participating in this project by assisting or being a subject.

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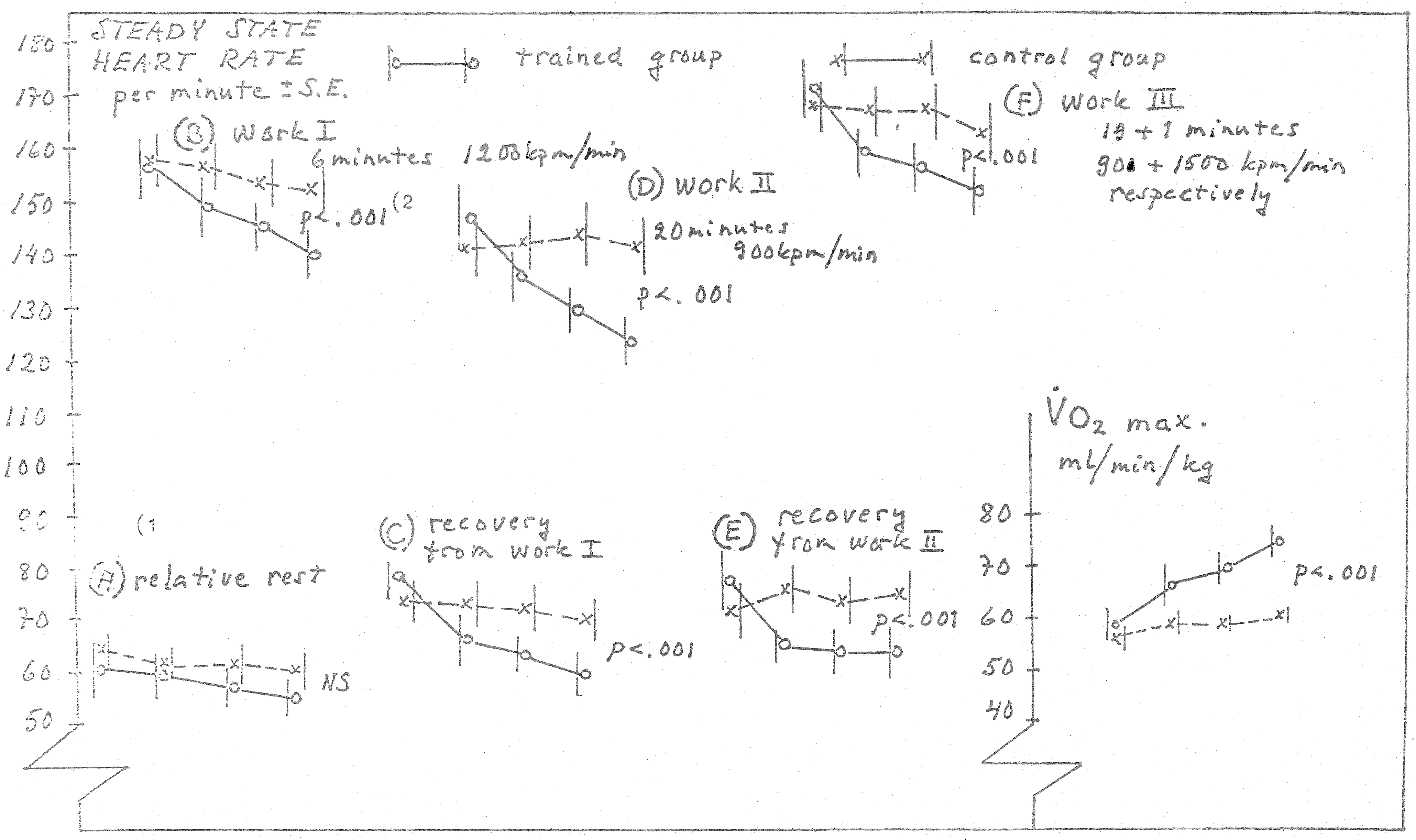
Minutes	
	arrival in laboratory 3 hours before 1st collection of urine; staying in laboratory
0	1st collection of urine
5	sample of blood
15	1st work on a bicycle ergometer: 6 minutes 1200 kpm/min
21	end of work I
26	sample of blood
	recovery in sitting position
55	2nd work on a bicycle ergometer: 20 minutes 900 kpm/min
75	end of work II
80	sample of blood
	recovery in sitting position
95	3rd work on a bicycle ergometer: 19 minutes 900 kpm/min + 1 minute 1500 kpm/min
115	end of work III
120	sample of blood
	staying in laboratory
	collection of urine one hour after the end of work III

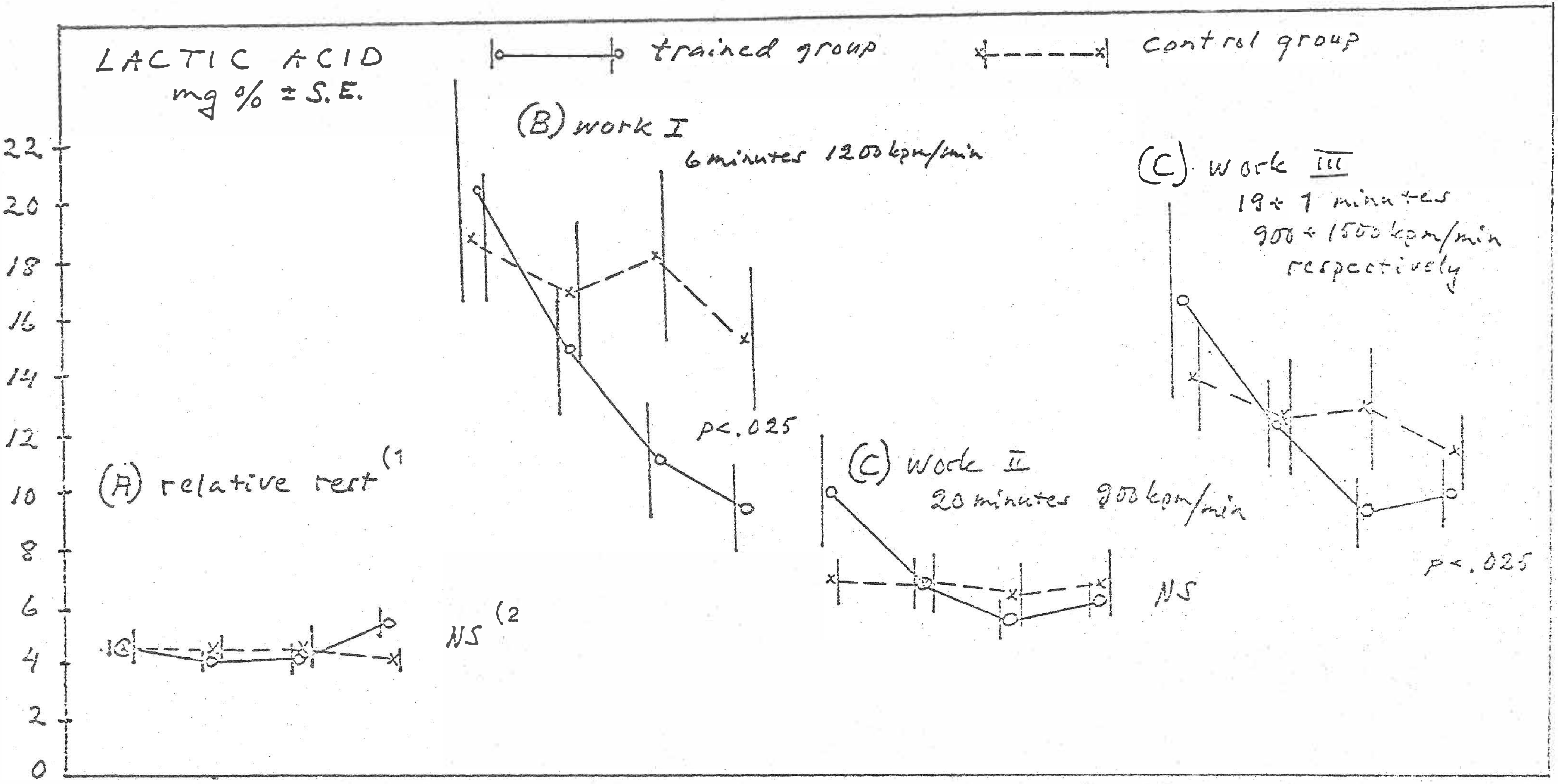
Fig. 1. Schedule of separate phases of the experiment



(1 the four successive points in lines respect the measurements 0, 3, 6 and 9 weeks after the outset of training (M_0, M_3, M_6 and M_9)

(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 2. Predicted maximal capacity of O_2-uptake and steady state heart rate per minute during relative rest, submaximal exercise and recovery during nine weeks' period of endurance conditioning.



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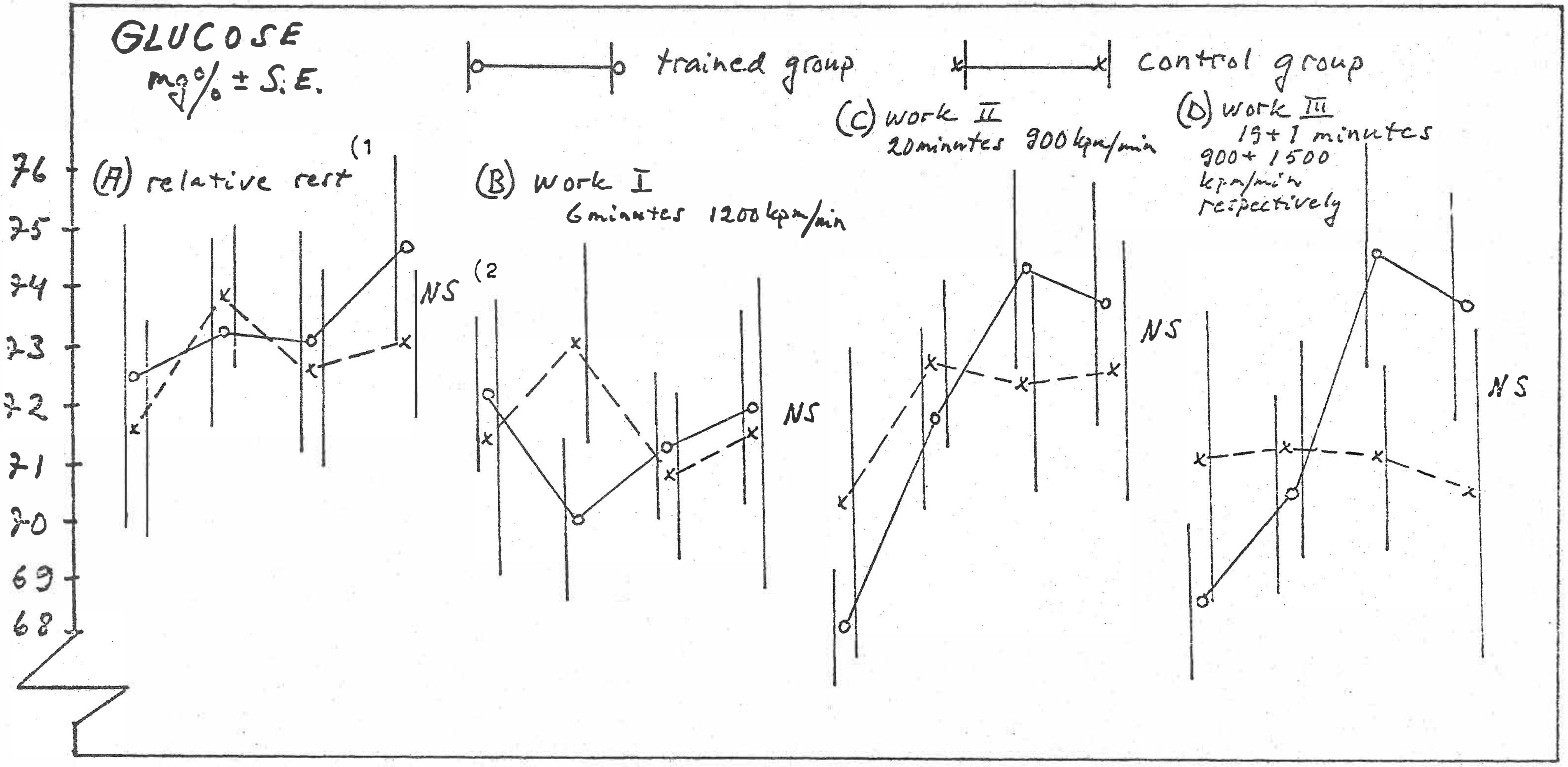
(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 3. Plasma lactic acid during relative rest and after exercise during a period of endurance conditioning.



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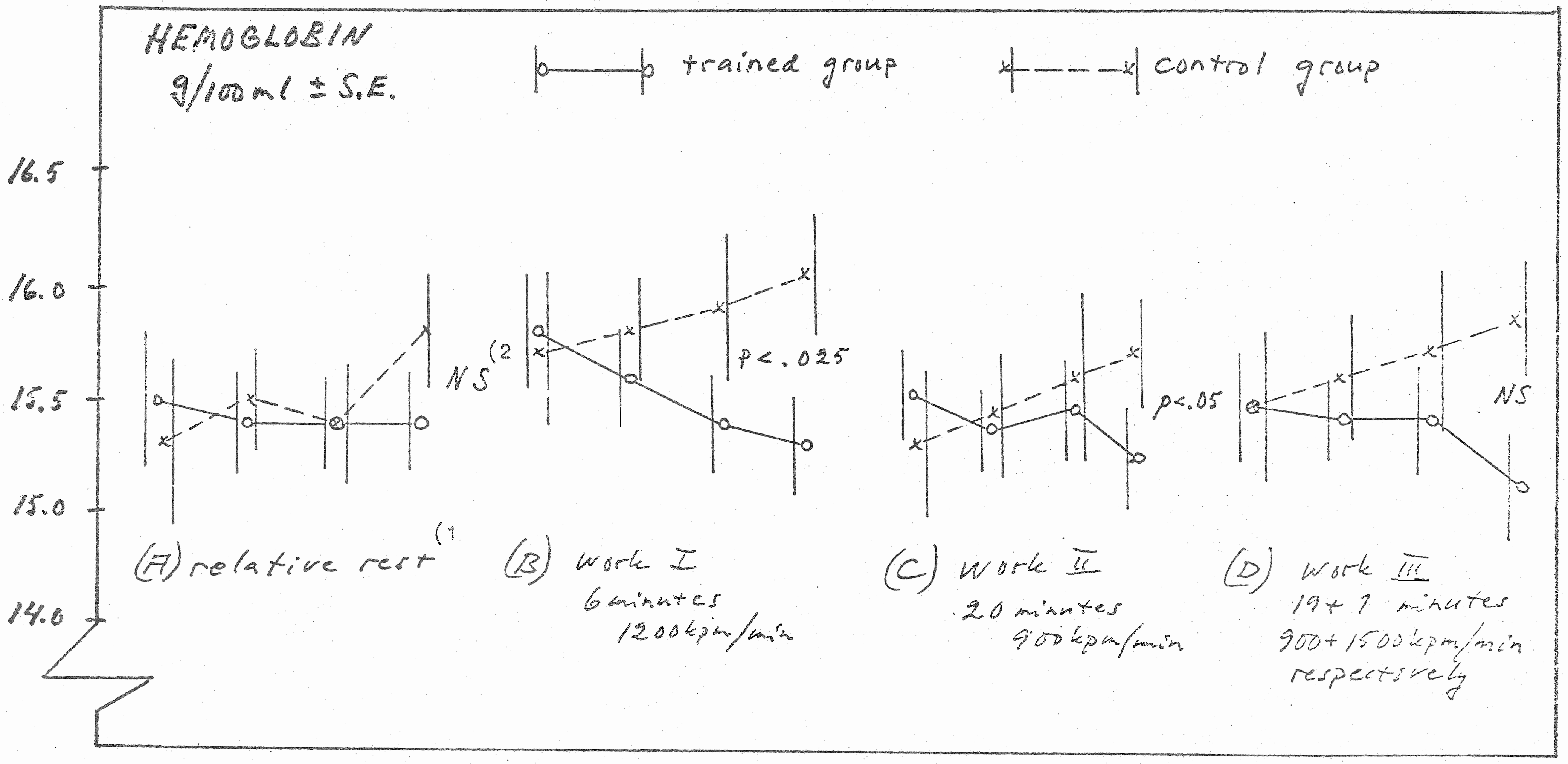
(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 4. Blood glucose concentration during relative rest and after exercise during a period of endurance conditioning.



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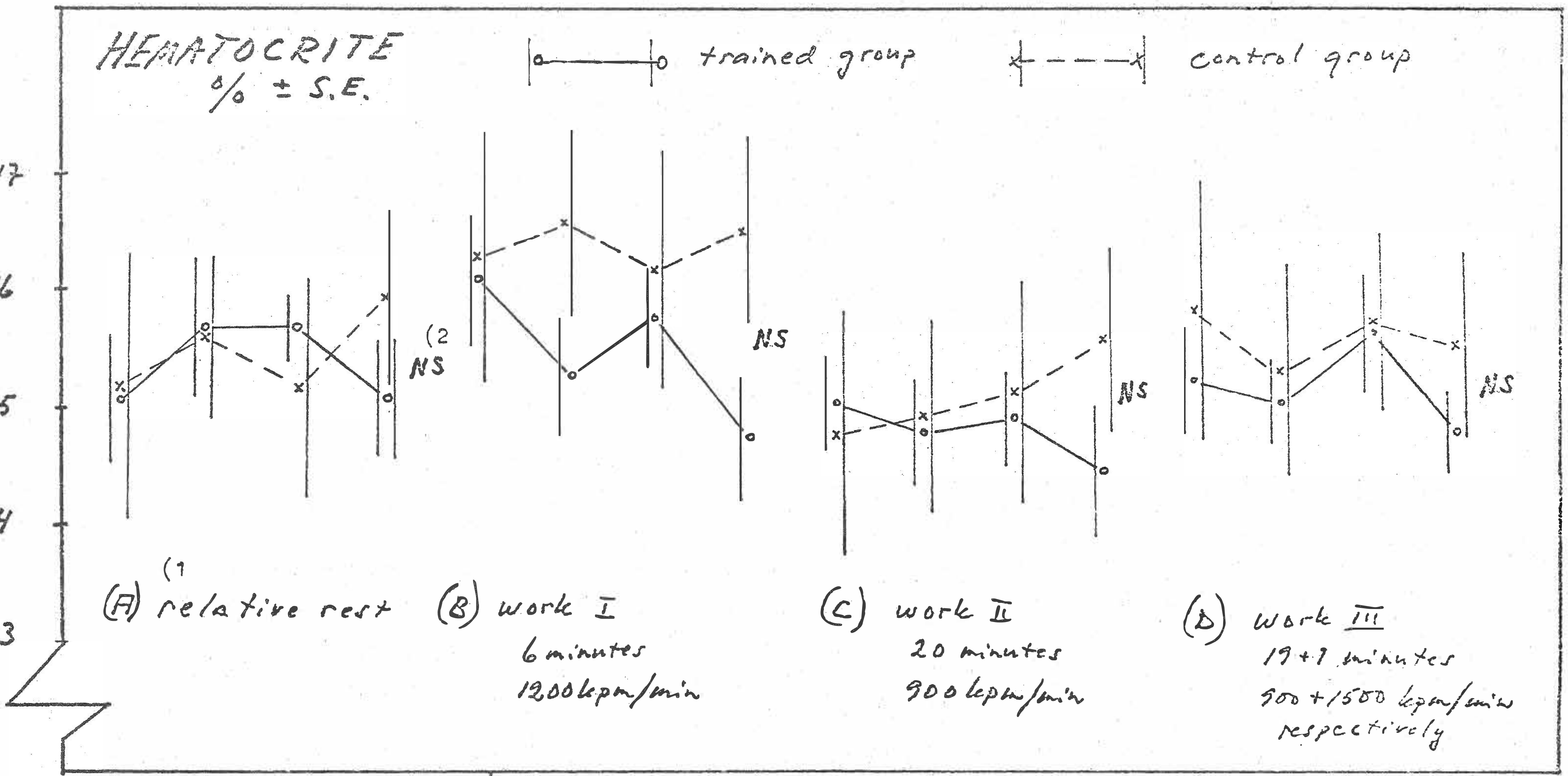
(2 all p-values from analyses of covariance M_0 as covariate

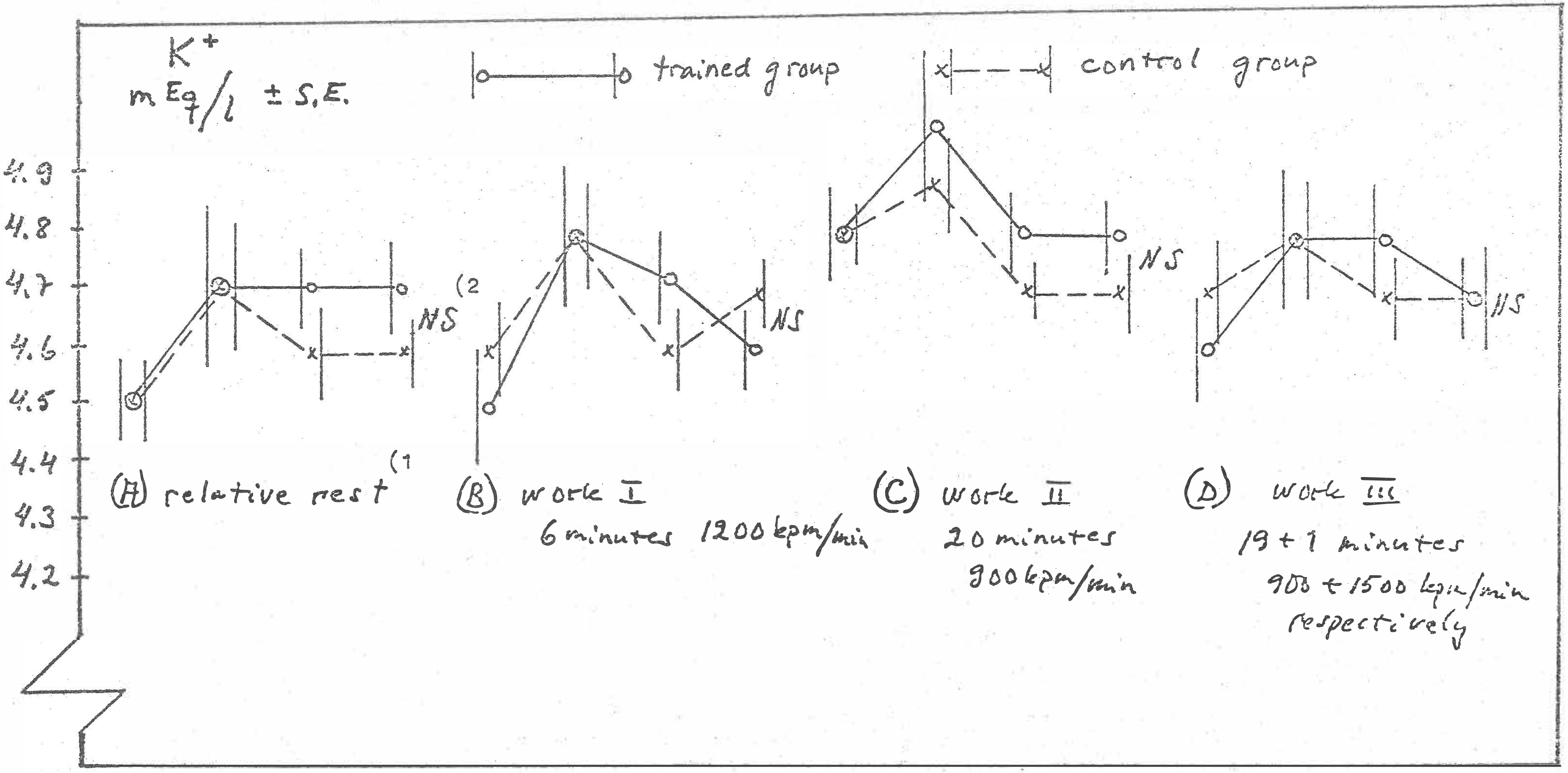
Fig. 5. Hemoglobin during relative rest and after exercise during a period of endurance conditioning.



(1 the four successive points in lines respect the measurements 0, 3, 6 and 9 weeks after the outset of training (M_0, M_3, M_6 and M_9)

(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 6. Hematocrite during relative rest and after exercise during a period of endurance conditioning.



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(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 7. Plasma-K^+ during relative rest and after exercise during a period of endurance conditioning.

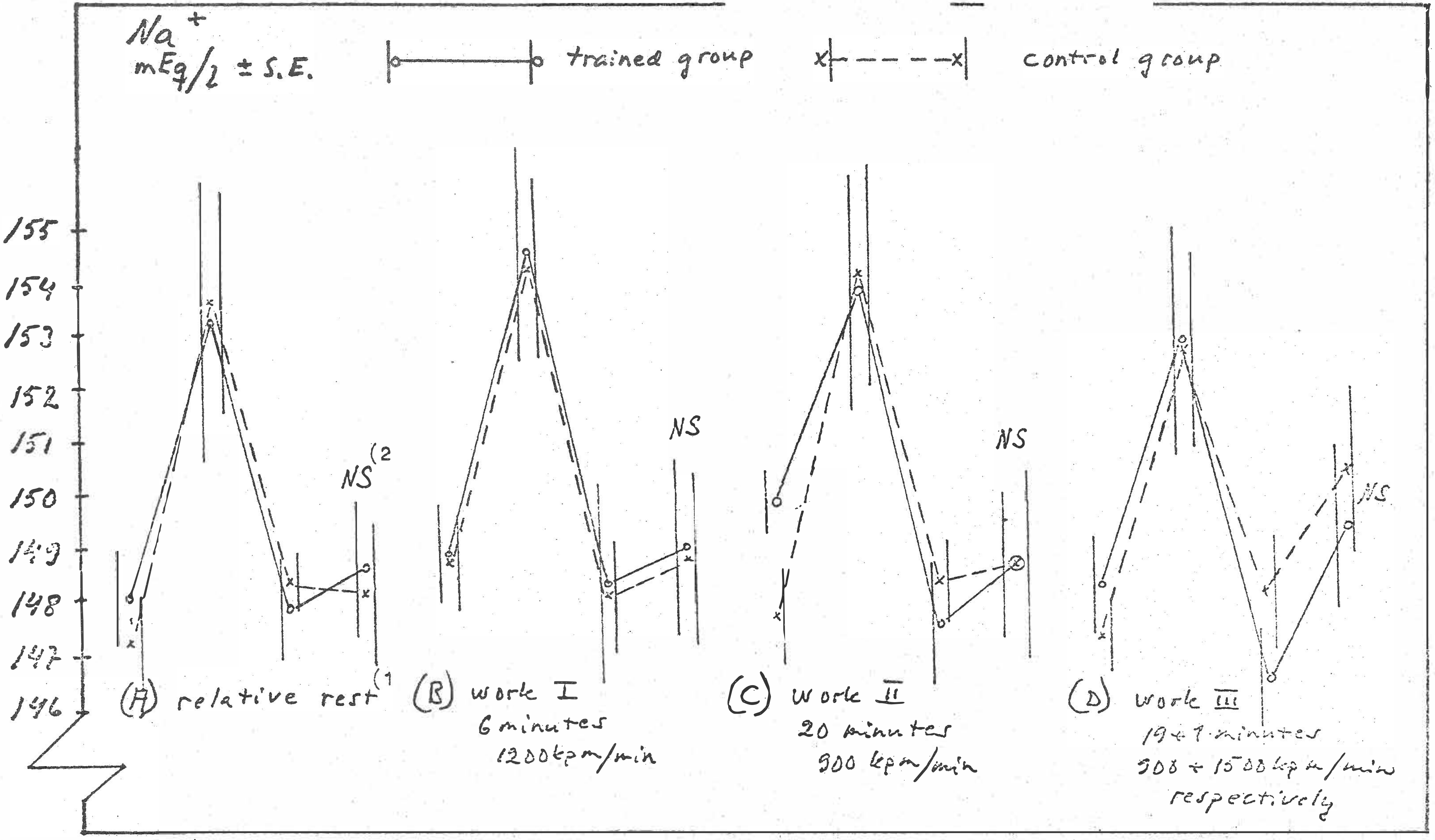

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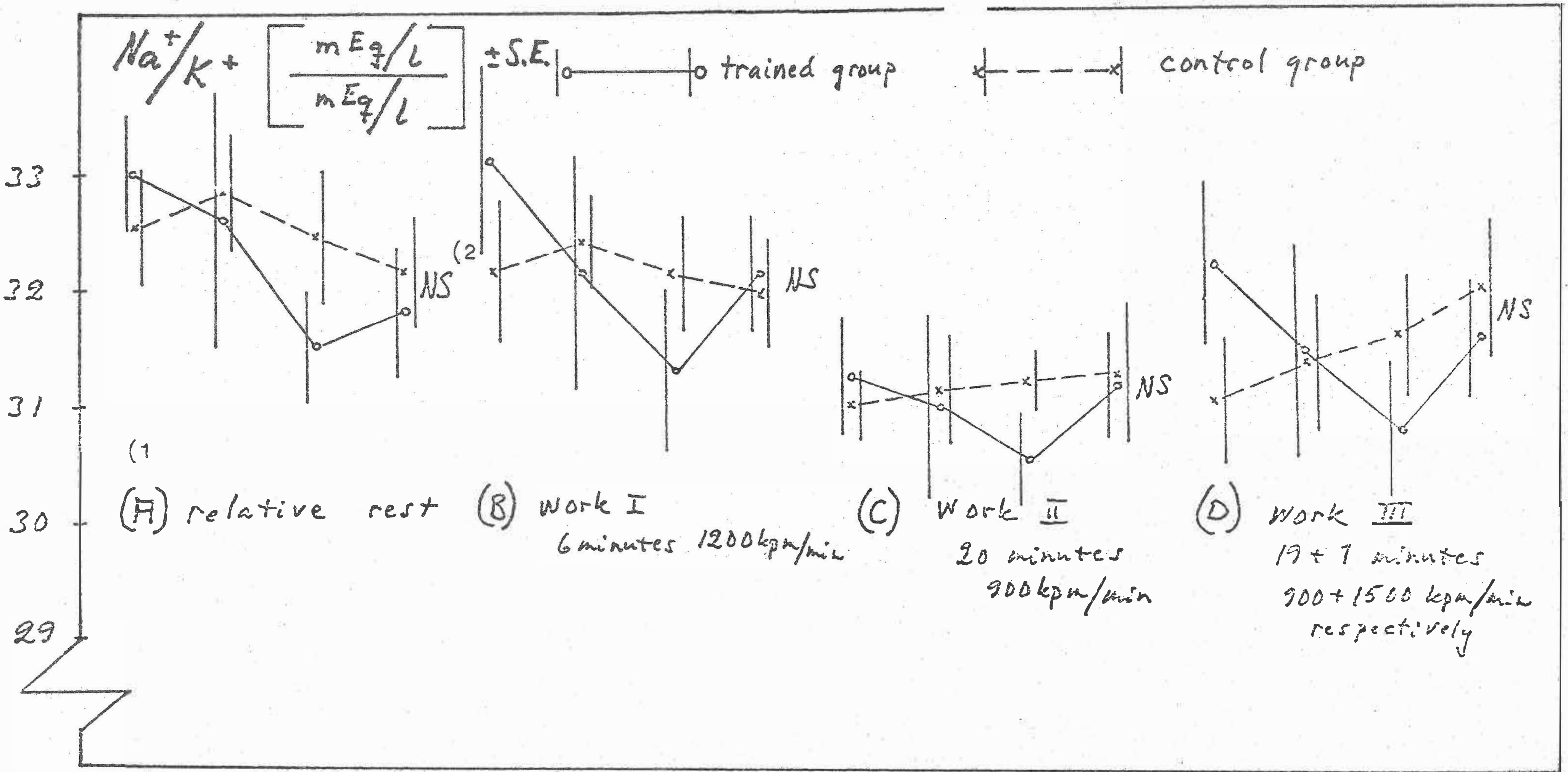
Fig. 8. Plasma-Na^+ during relative rest and after exercise during a period of endurance conditioning.



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(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 9. The ratio of plasma-Na^+ and -K^+ (Na^+/K^+) during relative rest and after exercise during a period of endurance conditioning

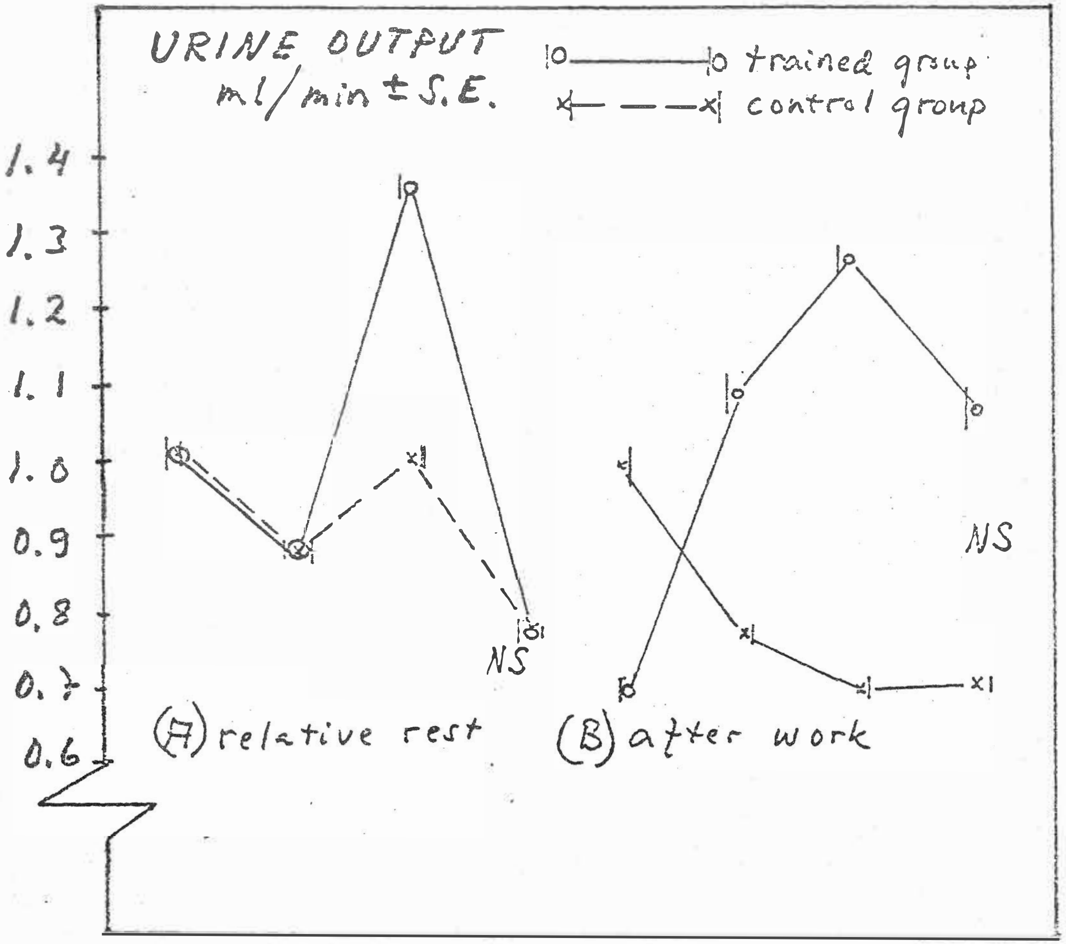

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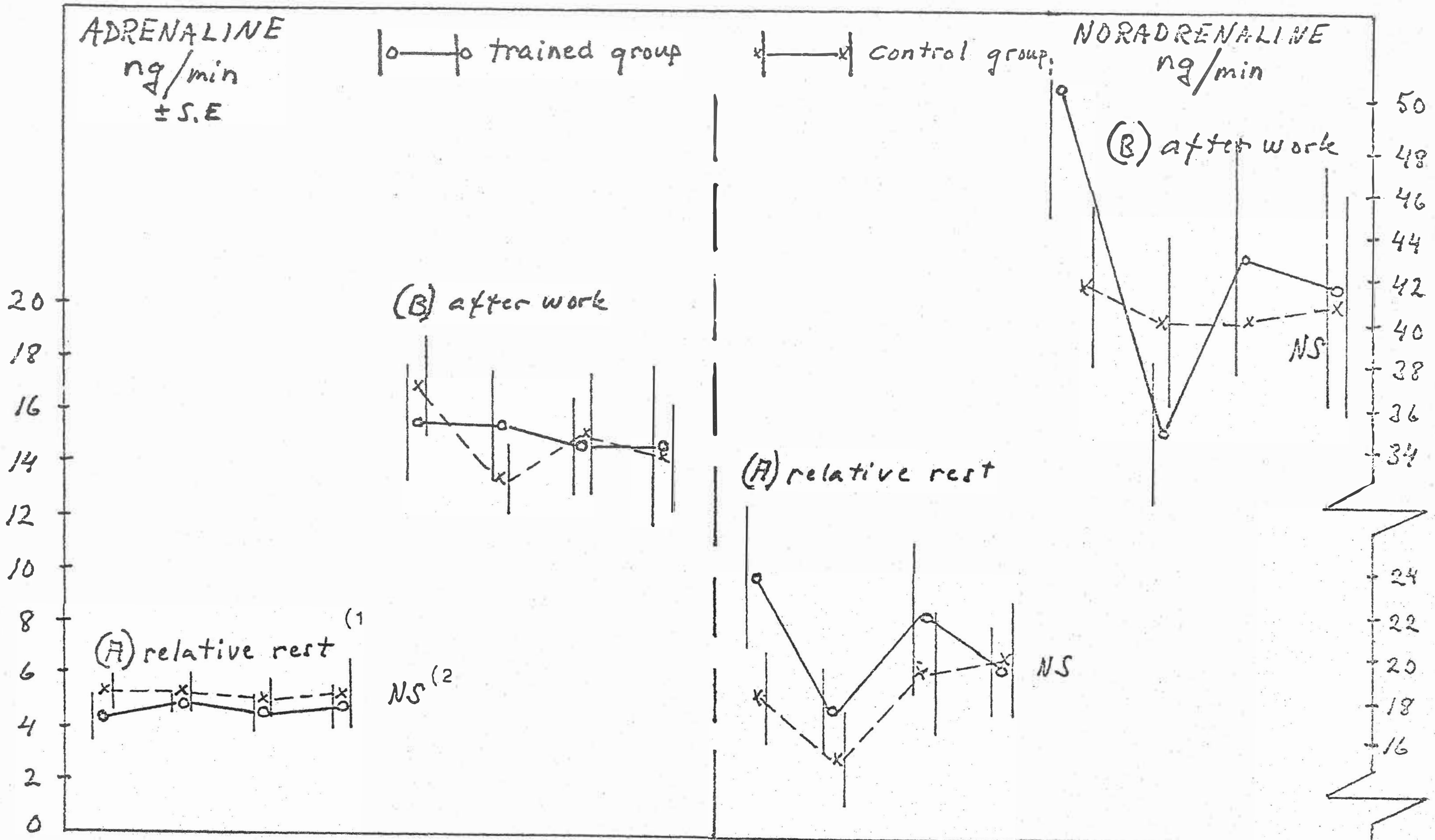
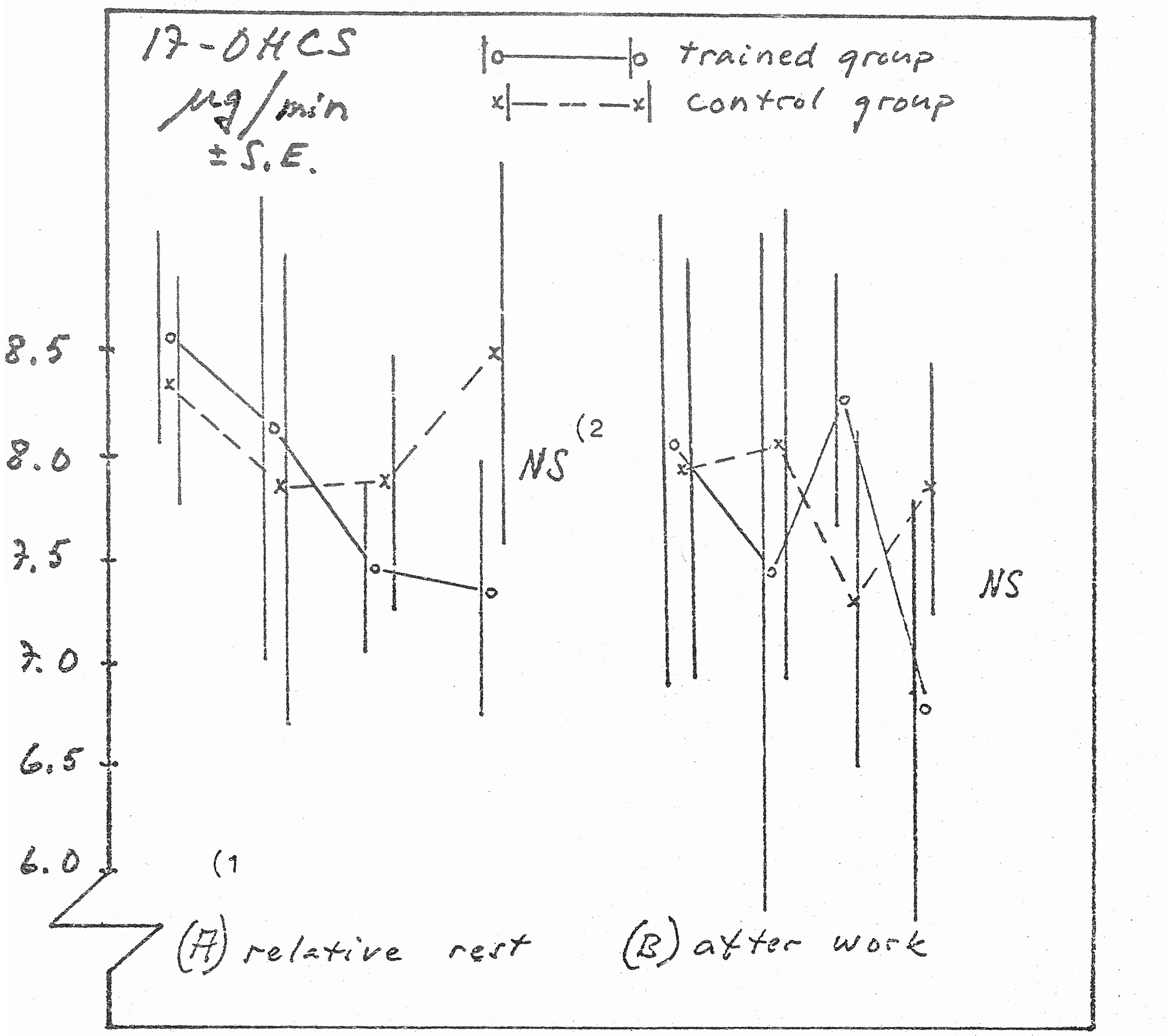
Fig. 10. Urine output during relative rest and exercise of total 46 minutes on a bicycle ergometer during a period of endurance conditioning



(1 the four successive points in lines respect the measurements 0, 3, 6 and 9 weeks after the outset of training (M_0, M_3, M_6 and M_9)

(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 11. Urinary excretion of noradrenaline and adrenaline during relative rest and exercise of total 46 minutes on a bicycle ergometer during a period of endurance conditioning.



(1 the four successive points in lines respect the measurements 0, 3, 6 and 9 weeks after the outset of training (M_0, M_3, M_6 and M_9)

(2 all p-values from analyses of covariance for between group difference M_0 as covariate

Fig. 12. Urinary excretion of 17-OHCS during relative rest and exercise of total 46 minutes on a bicycle ergometer during a period of endurance conditioning.

TABLE I SUBJECTS: GROUP MEANS ± S.E. FOR DESCRIPTIVE DATA

Subjects	Age (years)	Height (cm)	Weight (kg) [1] M_0	M_3	M_6	M_9
Control group (11)	24 ± 0.73	177 ± 1.87	68.0 ± 3.16	68.0 ± 3.00	68.3 ± 2.96	68.5 ± 3.02
Trained group (11)	25 ± 0.76	175 ± 2.03	67.9 ± 2.34	67.7 ± 2.99	67.7 ± 2.46	67.7 ± 2.56

[1] M_0 = before training; M_3 - M_9 = 3, 6, 9 weeks after the outset of training

TABLE II. PREDICTED MAXIMAL CAPACITY OF O_2-UPTAKE AND STEADY STATE HEART RATE PER MINUTE DURING RELATIVE REST, SUBMAXIMAL PHYSICAL WORK AND RECOVERY DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning, Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

Subjects	Measurement during training period [1]	During relative rest	During ergometer work I; 6 minutes 1200 kpm/min.	During recovery from work I	During ergometer work II; 20 minutes 900 kpm/min.	During recovery from work II	During ergometer work III; 19 + 1 minutes 900 + 1500 kpm/min. respect	Predicted $\dot{V}_{O_2}$ max. ml/min/kg of weight [3]
Control group (11)	M_0	[2] 64 ± 2.9	159 ± 5.0	73 ± 4.1	141 ± 5.3	70 ± 5.2	169 ± 4.9	57 ± 2.3
	M_3	60 ± 2.9	157 ± 4.5	73 ± 4.3	142 ± 5.3	74 ± 5.4	167 ± 4.8	59 ± 2.3
	M_6	63 ± 3.8	156 ± 4.4	72 ± 4.4	143 ± 5.6	71 ± 4.4	168 ± 5.1	59 ± 1.9
	M_9	60 ± 3.5	154 ± 4.4	71 ± 4.2	141 ± 5.4	73 ± 4.3	165 ± 5.1	60 ± 1.6
		[4] NS	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Trained group (11)	M_0	60 ± 4.6	158 ± 5.5	74 ± 4.6	149 ± 6.0	78 ± 5.8	171 ± 5.4	59 ± 3.0
	M_3	60 ± 4.3	148 ± 5.5	64 ± 4.9	134 ± 4.9	65 ± 3.1	158 ± 4.6	66 ± 4.0
	M_6	57 ± 3.6	145 ± 4.4	64 ± 3.6	129 ± 4.4	64 ± 4.1	156 ± 4.6	69 ± 3.0
	M_9	56 ± 3.5	139 ± 4.6	60 ± 4.2	123 ± 4.6	64 ± 5.0	150 ± 4.6	74 ± 3.0

1 M_0 = before training; M_3—M_9 = 3, 6 and 9 weeks after the beginning of training
2 numbers are Mean ± S.E.
3 with the indirect method of estimation of Åstrand and Ryhming (1954)
4 analysis of covariance for between group difference; M_0 as covariate, M_3—M_9 as criterion

TABLE III. LACTIC ACID AND BLOOD GLUCOSE DURING RELATIVE REST AND AFTER PHYSICAL WORK DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning, Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

			(A) During relative rest				(B) 5 minutes after work I; 6 minutes 1200 kpm/min			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Lactic acid mg %	Control group	$\bar{X}$	4.7	4.5	4.5	4.1	18.6	17.0	18.1	15.7
		S.E.	0.58	0.38	0.68	0.35	2.14	2.42	2.97	2.52
				[2] F = 0.316				[2] F = 6.863 $p < .025$		
	Trained group	$\bar{X}$	4.7	4.0	4.4	5.3	20.3	14.6	11.5	9.4
		S.E.	0.24	0.34	0.54	0.48	4.07	2.17	2.01	1.54
	Total	$\bar{X}$	4.7	[3] (A) — (B) $p < .001$			19.5	[3] (B) — (C) $p < .001$		
Glucose mg %	Control group	$\bar{X}$	71.4	73.8	72.4	73.0	71.1	73.2	70.8	71.7
		S.E.	1.84	1.20	1.69	1.25	2.34	1.71	1.43	2.66
				[2] F = 0.055 NS				[2] F = 0.488 NS		
	Trained group	$\bar{X}$	72.5	73.2	73.0	74.7	72.2	70.0	71.3	72.0
		S.E.	2.62	1.63	1.90	1.58	1.32	1.39	1.26	1.67
	Total	$\bar{X}$	72.0	[3] (A) — (B) NS			71.6	[3] (B) — (C) NS		

			(C) 5 minutes after work II; 20 minutes 900 kpm/min				(D) 5 minutes after work III; 19 + 1 minutes 900 + 1500 kpm/min, respectively			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Lactic acid mg %	Control group	$\bar{X}$	6.8	6.7	6.5	6.9	13.8	12.2	12.9	11.1
		S.E.	0.78	0.99	1.08	1.16	1.81	2.04	2.09	1.32
				[2] F = 2.498 NS				[2] F = 7.487 p = .025		
	Trained group	$\bar{X}$	10.0	6.7	5.5	6.1	16.3	12.1	9.3	9.7
		S.E.	1.97	0.85	0.70	0.58	3.19	1.54	1.31	1.19
	Total	$\bar{X}$	8.4	[3] (A) — (C) $p < .001$			15.0	[3] (A) — (D) $p < .001$; (C) — (D) $p < .001$		
Glucose mg %	Control group	$\bar{X}$	70.2	72.9	72.5	72.7	71.1	71.5	71.4	70.5
		S.E.	2.66	1.41	1.85	2.21	2.49	1.86	1.58	2.79
				[2] F = 0.819 NS				[2] F = 2.348 NS		
	Trained group	$\bar{X}$	68.3	72.0	74.3	73.8	68.3	70.3	74.5	73.7
		S.E.	0.98	1.55	1.71	2.06	1.31	1.71	1.94	1.94
	Total	$\bar{X}$	69.2	[3] (A) — (C) NS			69.7	[3] (A) — (D) NS; (C) — (D) NS		

1 M_0 = before training; M_3 — M_9 = 3, 6, 9 weeks after the beginning of training.
2 analysis of covariance for the between group difference; M_0 as covariate, M_3 — M_9 as criterion.
3 t-test for the total means in M_0.

TABLE IV. HEMOGLOBIN AND HEMATOCRITE DURING RELATIVE REST AND AFTER PHYSICAL WORK DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning, Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

			(A) During relative rest				(B) 5 minutes after work I; 6 minutes 1200 kpm/min			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Hemoglobin g/100 ml	Control group	$\overline{X}$	15.3	15.5	15.4	15.8	15.7	15.8	15.9	16.1
		S.E.	0.36	0.22	0.26	0.25	0.32	0.23	0.32	0.26
				[2] F = 1.643 NS				[2] $F = 6.018$ $p < .025$		
	Trained group	$\overline{X}$	15.5	15.4	15.4	15.4	15.8	15.6	15.4	15.3
		S.E.	0.29	0.23	0.19	0.20	0.25	0.21	0.21	0.21
	Total	$\overline{X}$	15.4	[3] (A) — (B) $p < .05$			15.7	[3] (B) — (C) $p < .01$		
Hematocrite %	Control group	$\overline{X}$	45.2	45.5	45.2	45.9	46.3	46.6	46.2	46.5
		S.E.	1.14	0.72	0.93	0.76	1.08	0.82	1.01	0.81
				[2] F = 0.017 NS				[2] F = 3.710 NS		
	Trained group	$\overline{X}$	45.1	45.6	45.6	45.1	46.1	45.3	45.7	44.7
		S.E.	0.56	0.60	0.28	0.51	0.57	0.49	0.43	0.54
	Total	$\overline{X}$	45.2	[3] (A) — (B) $p < .01$			46.2	[3] (B) — (C) $p < .001$		

			(C) 5 minutes after work II; 20 minutes 900 kpm/min				(D) 5 minutes after work III; 19 + 1 minutes 900 + 1500 kpm/min, respectively			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Hemoglobin g/100 ml	Control group	$\overline{X}$	15.3	15.5	15.7	15.8	15.5	15.6	15.7	15.9
		S.E.	0.32	0.28	0.37	0.24	0.33	0.28	0.35	0.24
				[2] $F = 4.381$ $p < .05$				[2] F = 2.991 NS		
	Trained group	$\overline{X}$	15.6	15.4	15.5	15.3	15.6	15.5	15.5	15.2
		S.E.	0.19	0.18	0.22	0.22	0.24	0.17	0.24	0.22
	Total	$\overline{X}$	15.4	[3] (A) — (C) NS			15.6	[3] (A) — (D) NS; (C) — (D) NS		
Hematocrite %	Control group	$\overline{X}$	44.7	44.9	45.1	45.6	45.6	45.4	45.8	45.6
		S.E.	1.04	0.83	0.95	0.79	1.11	0.91	0.77	0.79
				[2] F = 2.480 NS				[2] F = 0.299 NS		
	Trained group	$\overline{X}$	45.0	44.8	44.9	44.3	45.3	45.1	45.7	44.8
		S.E.	0.42	0.44	0.39	0.56	0.46	0.36	0.49	0.36
	Total	$\overline{X}$	44.9	[3] (A) — (C) NS			45.5	[3] (A) — (D) NS; (C) — (D) $p < .02$		

[1] M_0 = before training; $M_3 - M_9$ = 3, 6, 9 weeks after the beginning of training.
[2] analysis of covariance for the between group difference; M_0 as covariate, $M_3 - M_9$ as criterion.
[3] t-test for the total means in M_0.

TABLE V. PLASMA — K^+ AND — Na^+ DURING RELATIVE REST AND AFTER PHYSICAL WORK DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning, Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

			(A) During relative rest				(B) 5 minutes after work I; 6 minutes 1200 kpm/min			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Plasma K^+ mEq/l	Control group	$\overline{X}$	4.5	4.7	4.6	4.6	4.6	4.8	4.6	4.7
		S.E.	0.07	0.11	0.08	0.06	0.08	0.09	0.07	0.06
				[2] F = 2.057 NS				[2] F = 1.892 NS		
	Trained group	$\overline{X}$	4.5	4.7	4.7	4.7	4.5	4.8	4.7	4.6
		S.E.	0.07	0.14	0.07	0.08	0.10	0.12	0.08	0.07
	Total	$\overline{X}$	4.5	[3] (A) — (B) NS			4.6	[3] (B) — (C) $p < .001$		
Plasma Na^+ mEq/l	Control group	$\overline{X}$	147.2	153.7	148.2	148.0	148.6	154.2	148.0	148.7
		S.E.	0.91	2.10	0.56	1.37	0.91	1.70	1.01	1.62
				[2] F = 0.129 NS				[2] F = 0.231 NS		
	Trained group	$\overline{X}$	148.0	153.1	147.9	148.5	148.7	154.6	148.1	148.9
		S.E.	0.92	2.62	0.95	1.30	0.93	2.09	1.90	1.65
	Total	$\overline{X}$	147.6	[3] (A) — (B) NS			148.7	[3] (B) — (C) NS		

			(C) 5 minutes after work II; 20 minutes 900 kpm/min				(D) 5 minutes after work III; 19 + 1 minutes 900 + 1500 kpm/min, respectively			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Plasma K^+ mEq/l	Control group	$\overline{X}$	4.8	4.9	4.7	4.7	4.7	4.8	4.7	4.7
		S.E.	0.05	0.08	0.05	0.07	0.09	0.10	0.07	0.09
				[2] F = 0.395 NS				[2] F = 0.734 NS		
	Trained group	$\overline{X}$	4.8	5.0	4.8	4.8	4.6	4.8	4.8	4.7
		S.E.	0.08	0.13	0.07	0.06	0.09	0.12	0.10	0.07
	Total	$\overline{X}$	4.8	[3] (A) — (C) $p < .001$			4.7	[3] (A) — (D) $p < .05$; (C) — (D) NS		
Plasma Na^+ mEq/l	Control group	$\overline{X}$	147.6	154.2	148.3	148.7	147.2	152.7	148.0	150.5
		S.E.	0.90	2.16	0.79	1.79	0.69	1.81	1.08	1.55
				[2] F = 0.164 NS				[2] F = 0.520 NS		
	Trained group	$\overline{X}$	149.8	153.9	147.3	148.7	148.3	152.8	146.2	149.2
		S.E.	0.60	2.23	1.15	1.38	0.91	2.18	0.94	1.55
	Total	$\overline{X}$	148.7	[3] (A) — (C) NS			147.8	[3] (A) — (D) NS; (C) — (D) NS		

[1] M_0 = before training; $M_3 - M_9$ = 3, 6, 9 weeks after the beginning of training.
[2] analysis of covariance for the between group difference; M_0 as covariate, $M_3 - M_9$ as criterion.
[3] t-test for the total means in M_0.

TABLE VI. THE RATIO OF PLASMA — Na^+ AND — K^+ (Na^+/K^+) DURING RELATIVE REST AND AFTER PHYSICAL WORK DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning, Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

			(A) During relative rest				(B) 5 minutes after work I; 6 minutes 1200 kpm/min			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Na^+/K^+ mEq/l / mEq/l	Control group	$\overline{X}$	32.5	32.8	32.4	32.2	32.2	32.4	32.2	32.0
		S.E.	0.52	0.50	0.57	0.47	0.58	0.43	0.49	0.48
				[2] $F = 2.222$ NS				[2] $F = 1.277$ NS		
	Trained group	$\overline{X}$	33.0	32.6	31.5	31.9	33.1	32.2	31.3	32.2
		S.E.	0.44	1.11	0.46	0.55	0.84	1.00	0.68	0.51
	Total	$\overline{X}$	32.7	[3] (A) — (B) NS			32.7	[3] (B) — (C) $p < .001$		

			(C) 5 minutes after work II; 20 minutes 900 kpm/min				(D) 5 minutes after work III; 19 + 1 minutes 900 + 1500 kpm/min, respectively			
			[1] M_0	M_3	M_6	M_9	[1] M_0	M_3	M_6	M_9
Na^+/K^+ mEq/l / mEq/l	Control group	$\overline{X}$	31.0	31.2	31.3	31.4	31.1	31.6	31.8	32.1
		S.E.	0.29	0.47	0.25	0.59	0.54	0.59	0.53	0.61
				[2] $F = 1.924$ NS				[2] $F = 1.598$ NS		
	Trained group	$\overline{X}$	31.3	31.0	30.6	31.3	32.3	31.7	30.8	31.8
		S.E.	0.50	0.80	0.41	0.45	0.67	0.92	0.62	0.51
	Total	$\overline{X}$	31.2	[3] (A) — (C) $p < .001$			31.7	[3] (A) — (D) $p < .05$; (C) — (D) NS		

[1] M_0 = before training; M_3 — M_9 = 3, 6, 9 weeks after the beginning of training.
[2] analysis of covariance for the between group difference; M_0 as covariate, M_3 — M_9 as criterion.
[3] t-test for the total means in M_0.

TABLE VII. URINE OUTPUT AND URINARY EXCRETION OF CATECHOLAMINES AND 17-OHCS DURING RELATIVE REST AND WORK ON A BICYCLE ERGOMETER DURING A NINE-WEEK PERIOD OF ENDURANCE CONDITIONING

(From the report SARVIHARJU, P. J.: Urinary excretion of catecholamines, 17-hydroxycorticosteroids and concentration of certain blood parameters during progressive endurance conditioning. Public Health Publication no. 15, 1972, University of Jyväskylä, Finland)

Variable	Groups n = 11	During relative rest: Measurement during training period (M) Index numbers are weeks after the outset				Test for loading effect [1]
		M_0	M_3	M_6	M_9	p
Urine output	Control	1.03 ± 0.16	0.87 ± 0.16	1.02 ± 0.17	0.78 ± 0.13	< .01
ml/min	Trained	1.03 ± 0.23	0.88 ± 0.11	1.35 ± 0.16	0.81 ± 0.09	
Adrenaline (A)	Control	5.3 ± 0.90	5.0 ± 0.76	4.7 ± 0.71	5.1 ± 1.31	< .001
ng/min	Trained	4.2 ± 0.68	4.8 ± 0.30	4.3 ± 0.74	4.6 ± 0.82	
Noradrenaline (NA)	Control	18.6 ± 1.76	15.3 ± 1.82	18.8 ± 2.28	19.5 ± 2.17	< .001
ng/min	Trained	23.6 ± 2.65	17.3 ± 1.80	22.1 ± 2.98	19.3 ± 1.71	
NA + A	Control	24.0 ± 2.36	20.3 ± 1.93	23.6 ± 2.99	24.7 ± 3.08	< .001
ng/min	Trained	27.9 ± 3.05	22.1 ± 1.98	26.4 ± 3.43	23.8 ± 2.08	
NA/A	Control	4.5 ± 0.87	4.4 ± 1.02	4.5 ± 0.60	5.2 ± 0.75	< .01
	Trained	6.3 ± 0.93	3.6 ± 0.29	6.1 ± 0.84	6.2 ± 1.49	
Δ A	Control					
ng/min	Trained					
Δ NA	Control		Δ-NUMBERS TO RIGHT INDICATE THE CHANGE FROM REST TO WORK			
ng/min	Trained					
Δ NA + A	Control					
ng/min	Trained					
17-OHCS	Control	8.3 ± 0.67	7.9 ± 1.06	7.9 ± 0.55	8.5 ± 0.93	NS
μg/min	Trained	8.7 ± 0.60	8.2 ± 1.01	7.5 ± 0.42	7.4 ± 0.59	

Variable	Groups n = 11	During work of 46 minutes: Measurement during training period (M) Index numbers are weeks after the outset				Test for training effect [2]	
		M_0	M_3	M_6	M_9	During rest	During work
Urine output	Control	0.98 ± 0.24	0.77 ± 0.13	0.73 ± 0.13	0.74 ± 0.09	F = 0.785	F = 1.491
ml/min	Trained	0.73 ± 0.19	1.11 ± 0.26	1.27 ± 0.19	1.08 ± 0.29		
Adrenaline (A)	Control	16.9 ± 1.94	13.0 ± 1.31	15.1 ± 2.25	14.1 ± 2.03	F = 0.042	F = 0.068
ng/min	Trained	15.7 ± 2.20	15.6 ± 2.08	14.6 ± 1.82	15.0 ± 2.99		
Noradrenaline (NA)	Control	42.0 ± 3.04	36.2 ± 3.21	40.2 ± 5.28	41.8 ± 4.17	F = 0.134	F = 0.373
ng/min	Trained	50.2 ± 4.94	34.5 ± 2.71	43.0 ± 4.43	41.1 ± 4.51		
NA + A	Control	58.9 ± 3.69	49.2 ± 3.83	55.3 ± 6.42	56.0 ± 5.49	F = 0.653	F = 0.170
ng/min	Trained	65.9 ± 6.45	50.0 ± 3.42	57.5 ± 5.91	56.1 ± 7.15		
NA/A	Control	2.8 ± 0.37	3.1 ± 0.38	3.0 ± 0.35	3.3 ± 0.38	F = 0.423	F = 1.320
	Trained	3.9 ± 0.67	2.7 ± 0.32	3.2 ± 0.34	3.3 ± 0.37		
Δ A	Control	10.7 ± 1.23	8.4 ± 0.85	10.8 ± 1.69	8.7 ± 1.08	—	F = 0.052
ng/min	Trained	10.8 ± 2.02	8.2 ± 1.22	10.3 ± 1.33	10.7 ± 2.42		
Δ NA	Control	23.5 ± 2.62	20.7 ± 2.74	22.0 ± 4.01	20.9 ± 1.89	—	F = 0.250
ng/min	Trained	24.7 ± 3.96	16.1 ± 1.86	21.2 ± 2.21	21.9 ± 3.99		
Δ NA + A	Control	34.1 ± 2.50	29.1 ± 3.09	31.8 ± 4.61	30.6 ± 2.45	—	F = 0.031
ng/min	Trained	35.5 ± 5.24	25.9 ± 2.40	31.5 ± 3.13	32.7 ± 6.03		
17-OHCS	Control	8.0 ± 0.95	8.1 ± 1.05	7.3 ± 0.78	7.9 ± 0.55	F = 0.161	F = 0.031
μg/min	Trained	8.1 ± 1.07	7.5 ± 1.58	8.3 ± 0.59	6.8 ± 0.99		

[1] t-test for the total means between rest and work in 0-situation
[2] analysis of covariance for the between group difference M_0 as covariate and M_3—M_9 as criterion

TABLE VIII SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON MAXIMAL $\dot{V}O_2$ AND STEADY STATE HEART RATE DURING RELATIVE REST AND PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Heart rate during rest				(B) Heart rate during work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	228.125	1	228.125	0.750	2234.000	1	2234.000	3.384
Subj. w.A	5468.719	18	303.817		13201.501	20	660.075	
Within subjects								
B (measurements)	45.687	2	22.843	0.506	406.500	2	203.250	8.699***
AB	83.218	2	41.609	0.922	111.750	2	55.875	2.391
B* subj. w.A	1624.437	36	45.123		934.500	40	23.362	
Total	7450.188				16888.253			
A (adj.)	52.410	1	52.410	0.298	1766.299	1	1766.299	15.443****
Subj. w.A (adj.)	2989.321	17	175.842		2173.050	19	114.371	

Source	(C) Heart rate during recovery from work I				(D) Heart rate at work II			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	1391.000	1	1391.000	2.775	3040.500	1	3040.500	4.025
Subj. w.A	10023.626	20	501.181		15105.001	20	755.250	
Within subjects								
B (measurements)	202.000	2	101.000	2.792	425.250	2	212.625	5.653***
AB	22.500	2	11.250	0.311	226.250	2	113.125	3.007
B* subj. w.A	1446.875	40	36.171		1504.500	40	37.612	
Total	13086.001				20301.503			
A (adj.)	1557.862	1	1557.862	19.747****	6035.458	1	6035.458	41.148****
Subj. w.A	1498.913	19	78.890		2786.813	19	146.674	

Source	(E) Heart rate during recovery from work II				(F) Heart rate at work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	1620.125	1	1620.125	3.146	2257.250	1	2257.250	3.337
Subj. w.A	10298.876	20	514.943		13526.751	20	676.337	
Within subjects								
B (measurements)	6.562	2	3.281	0.058	313.750	2	156.875	4.938**
AB	8.312	2	4.156	0.074	96.250	2	48.125	1.514
B* subj. w.A	2246.500	40	56.162		1270.750	40	31.768	
Total	14180.376				17464.753			
A (adj.)	3072.273	1	3072.273	22.298****	2924.870	1	2924.870	20.658****
Subj. w.A	2617.808	19	137.779		2690.054	19	141.581	

Source	(G) Maximal $\dot{V}O_2$			
	SS	df	MS	F
Between subjects				
A (groups)	1741.187	1	1741.187	7.875**
Subj. w.A	4422.063	20	221.103	
Within subjects				
B (measurements)	208.500	2	104.250	7.633***
AB	124.625	2	62.312	4.562**
B* subj. w.A	546.250	40	13.656	
Total	7042.625			
A (adj.)	1345.134	1	1345.134	20.619****
Subj. w.A	1239.459	19	65.234	

* $p < .05$

** $p < .025$

*** $p < .01$

**** $p < .001$

TABLE IX SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON PLASMA LACTIC ACID AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.854	1	0.854	0.224	425.632	1	425.632	2.658
Subj. w.A	76.272	20	3.813		3201.729	20	160.086	
Within subjects								
B (measurements)	2.476	2	1.238	0.669	122.667	2	61.333	7.367***
AB	8.225	2	4.112	2.223	59.615	2	29.807	3.580*
B* subj. w.A	73.983	40	1.849		333.009	40	8.325	
Total	161.812				4142.655			
A (adj.)	1.021	1	1.021	0.316	568.218	1	568.218	6.863**
Subj. w.A (adj.)	61.277	19	3.225		1573.065	19	82.792	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	5.303	1	5.303	0.248	49.250	1	49.250	0.679
Subj. w.A	427.020	20	21.351		1449.127	20	72.456	
Within subjects								
B (measurements)	5.570	2	2.785	0.891	36.103	2	18.051	2.518
AB	3.420	2	1.710	0.547	33.605	2	16.802	2.343
B* subj. w.A	124.978	40	3.124		286.750	40	7.168	
Total	566.293				1854.836			
A (adj.)	36.915	1	36.915	2.498	155.518	1	155.518	7.487**
Subj. w.A (adj.)	280.681	19	14.772		394.623	19	20.769	

* p .05
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE X SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON BLOOD GLUCOSE AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	5.500	1	5.500	0.127	11.875	1	11.875	0.213
Subj. w.A	865.187	20	43.259		1110.250	20	55.512	
Within subjects								
B (measurements)	17.375	2	8.687	0.467	8.000	2	4.000	0.176
AB	13.812	2	6.906	0.372	47.625	2	23.812	1.050
B * subj. w.A	742.562	40	18.564		906.812	40	22.670	
Total	1644.437				2084.562			
A (adj.)	2.113	1	2.113	0.055	22.655	1	22.655	0.488
Subj. w.A (adj.)	725.144	19	38.165		881.362	19	46.387	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	8.000	1	8.000	0.126	46.875	1	46.875	1.010
Subj. w.A	1261.562	20	63.078		927.812	20	46.390	
Within subjects								
B (measurements)	12.812	2	6.406	0.279	47.375	2	23.687	0.548
AB	19.500	2	9.750	0.425	65.937	2	32.968	0.762
B * subj. w.A	915.500	40	22.887		1728.687	40	43.217	
Total	2217.375				2816.687			
A (adj.)	35.094	1	35.094	0.819	91.746	1	91.746	2.348
Subj. w.A (adj.)	813.557	19	42.818		742.221	19	39.064	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XI SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON HEMOGLOBIN AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.634	1	0.634	0.419	3.277	1	3.277	1.897
Subj. w.A	30.234	20	1.511		34.537	20	1.726	
Within subjects								
B (measurements)	0.435	2	0.217	1.895	0.093	2	0.046	0.415
AB	0.666	2	0.333	2.898	0.867	2	0.433	3.840*
B * subj. w.A	4.595	40	0.114		4.515	40	0.112	
Total	36.566				43.291			
A (adj.)	1.149	1	1.149	1.643	3.683	1	3.683	6.018**
Subj. w.A (adj.)	13.286	19	0.699		11.626	19	0.611	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	1.232	1	1.232	0.655	2.078	1	2.078	1.131
Subj. w.A	37.574	20	1.878		36.736	20	1.836	
Within subjects								
B (measurements)	0.140	2	0.070	0.481	0.074	2	0.037	0.243
AB	0.388	2	0.194	1.331	1.486	2	0.743	4.867**
B * subj. w.A	5.835	40	0.145		6.107	40	0.152	
Total	45.171				46.482			
A (adj.)	3.269	1	3.269	4.324	2.930	1	2.930	2.991
Subj. w.A (adj.)	14.364	19	0.756		18.611	19	0.979	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XII SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON HEMATOCRITE AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.375	1	0.375	0.029	23.000	1	23.000	1.548
Subj. w.A	257.968	20	12.898		297.031	20	14.851	
Within subjects								
B (measurements)	0.593	2	0.296	0.341	2.250	2	1.125	1.131
AB	4.000	2	2.000	2.298	4.781	2	2.390	2.403
B * subj. w.A	34.812	40	0.870		39.781	40	0.994	
Total	297.750				366.843			
A (adj.)	0.079	1	0.079	0.017	18.210	1	18.210	3.710
Subj. w.A (adj.)	87.780	19	4.620		93.248	19	4.907	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	4.750	1	4.750	0.332	3.031	1	3.031	0.278
Subj. w.A	285.406	20	14.270		217.968	20	10.898	
Within subjects								
B (measurements)	0.531	2	0.265	0.374	4.437	2	2.218	1.470
AB	4.687	2	2.343	3.303*	0.906	2	0.453	0.300
B * subj. w.A	28.375	40	0.709		60.343	40	1.508	
Total	323.750				286.687			
A (adj.)	8.682	1	8.682	2.480	1.028	1	1.028	0.299
Subj. w.A (adj.)	66.501	19	3.500		65.261	19	3.434	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XIII SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON PLASMA - K^+ AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.090	1	0.090	0.560	0.063	1	0.063	0.487
Subj. w.A	3.214	20	0.160		2.605	20	0.130	
Within subjects								
B (measurements)	0.108	2	0.054	0.792	0.329	2	0.164	3.114
AB	0.020	2	0.010	0.148	0.063	2	0.031	0.601
B* subj. w.A	2.736	40	0.068		2.117	40	0.052	
Total	6.169				5.180			
A (adj.)	0.194	1	0.194	2.057	0.150	1	0.150	1.892
Subj. w.A (adj.)	1.800	19	0.094		1.515	19	0.079	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.053	1	0.053	0.399	0.018	1	0.018	0.097
Subj. w.A	2.665	20	0.133		3.625	20	0.181	
Within subjects								
B (measurements)	0.626	2	0.313	7.643***	0.278	2	0.139	2.853
AB	0.012	2	0.006	0.146	0.039	2	0.019	0.399
B* subj. w.A	1.639	40	0.041		1.948	40	0.049	
Total	4.996				5.907			
A (adj.)	0.031	1	0.031	0.395	0.106	1	0.106	0.734
Subj. w.A (adj.)	1.502	19	0.079		2.746	19	0.145	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XIV SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON PLASMA - Na^+ AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	2.500	1	2.500	0.114	4.000	1	4.000	0.192
Subj. w.A	436.000	20	21.800		415.500	20	20.775	
Within subjects								
B (measurements)	411.750	2	205.875	6.212***	533.250	2	266.625	7.228***
AB	2.500	2	1.250	0.037	-2.000	2	-1.000	-0.027
B* subj. w.A	1325.500	40	33.137		1475.500	40	36.887	
Total	2178.250				2426.250			
A (adj.)	2.812	1	2.812	0.129	4.949	1	4.949	0.231
Subj. w.A (adj.)	413.639	19	21.770		405.862	19	21.361	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	5.750	1	5.750	0.205	19.000	1	19.000	0.785
Subj. w.A	561.750	20	28.087		484.000	20	24.200	
Within subjects								
B (measurements)	505.000	2	252.500	7.981***	352.750	2	176.375	6.125***
AB	2.500	2	1.250	0.040	8.250	2	4.125	0.143
B* subj. w.A	1265.500	40	31.637		1151.750	40	28.794	
Total	2340.500				2015.750			
A (adj.)	4.853	1	4.853	0.164	11.933	1	11.933	0.520
Subj. w.A (adj.)	561.564	19	29.556		436.253	19	22.961	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XV SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON THE RATIO OF PLASMA - Na^+ AND - K^+ (Na^+/K^+) AT RELATIVE REST AND AFTER PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	(A) Rest				(B) Work I			
	SS	df	MS	F	SS	df	MS	F
<u>Between subjects</u>								
A (groups)	3.640	1	3.640	0.529	1.562	1	1.562	0.245
Subj. w.A	137.593	20	6.879		127.156	20	6.357	
<u>Within subjects</u>								
B (measurements)	7.125	2	3.562	0.992	3.093	2	1.546	0.462
AB	1.484	2	0.742	0.206	3.203	2	1.601	0.478
B* subj. w.A	143.640	40			133.921	40	3.348	
Total	293.484				268.937			
A (adj.)	9.820	1	9.820	2.222	5.709	1	5.709	1.277
Subj. w.A (adj.)	83.960	19	4.418		84.907	19	4.468	

Source	(C) Work II				(D) Work III			
	SS	df	MS	F	SS	df	MS	F
<u>Between subjects</u>								
A (groups)	2.484	1	2.484	0.480	2.672	1	2.672	0.314
Subj. w.A	103.516	20	5.176		170.125	20	8.506	
<u>Within subjects</u>								
B (measurements)	2.172	2	1.086	0.569	4.484	2	2.242	0.869
AB	1.297	2	0.648	0.340	3.156	2	1.578	0.612
B* subj. w.A	76.281	40	1.907		103.203	40	2.580	
Total	185.750				283.641			
A (adj.)	6.187	1	6.187	1.924	11.354	1	11.354	1.598
Subj. w.A (adj.)	61.094	19	3.215		134.988	19	7.105	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XVI SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON URINATION DURING RELATIVE REST AND PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	Urine ml/min							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.256	1	0.256	0.686	0.268	1	0.268	1.254
Subj. w.A	7.456	20	0.372		4.287	20	0.214	
Within subjects								
B (measurements)	1.787	2	0.893	6.287***	0.065	2	0.032	0.564
AB	0.355	2	0.177	1.249	0.288	2	0.144	2.470
B * subj. w.A	5.684	40	0.142		2.333	40	0.058	
Total	15.539				7.244			
A (adj.)	0.254	1	0.254	0.785	0.319	1	0.319	1.491
Subj. w.A (adj.)	6.155	19	0.323		4.075	19	0.214	

Source	Urine ml/min/kg of body weight							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.004	1	0.004	0.455	0.268	1	0.268	1.374
Subj. w.A	0.208	20	0.010		3.900	20	0.195	
Within subjects								
B (measurements)	0.035	2	0.017	6.411***	0.082	2	0.041	0.719
AB	0.009	2	0.004	1.725	0.280	2	0.140	2.446
B * subj. w.A	0.111	40	0.002		2.295	40	0.057	
Total	0.370				6.827			
A (adj.)	0.005	1	0.005	0.779	0.309	1	0.309	1.563
Subj. w.A (adj.)	0.139	19	0.007		3.754	19	0.197	

* $p < 0.05$
** $p < 0.025$
*** $p < 0.01$
**** $p < 0.001$

TABLE XVII SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON URINARY EXCRETION OF CATECHOLAMINES DURING RELATIVE REST AND PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	Adrenaline							
	(A) Rest				(B) Period of works I - III			
	SS							
Between subjects								
A (groups)	2.603	1	2.603	0.219	11.060	1	11.060	0.107
Subj. w.A	238.065	20	11.903		2052.891	20	102.644	
Within subjects								
B (measurements)	2.267	2	1.133	0.212	9.048	2	4.524	0.127
AB	0.436	2	0.218	0.041	20.351	2	10.175	0.287
B* subj. w.A	213.977	40	5.349		1417.683	40	35.442	
Total	457.347				3511.035			
A (adj.)	0.312	1	0.312	0.042	5.153	1	5.153	0.068
Subj. w.A (adj.)	141.801	19	7.463		1433.760	19	75.461	

Source	Noradrenaline							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	46.555	1	46.555	0.483	0.281	1	0.281	0.001
Subj. w.A	1929.316	20	96.466		7066.594	20	353.330	
Within subjects								
B (measurements)	206.590	2	103.295	3.513*	570.813	2	285.406	2.693
AB	36.449	2	18.225	0.620	63.375	2	31.688	0.299
B* subj. w.A	1176.227	40	29.406		4238.875	40	105.972	
Total	3395.137				11939.938			
A (adj.)	8.063	1	8.063	0.134	113.610	1	113.610	0.373
Subj. w.A (adj.)	1143.442	19	60.181		5786.320	19	304.543	

* $p < 0.05$
** $p < 0.025$
*** $p < 0.01$
**** $p < 0.001$

TABLE XVIII SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON URINARY EXCRETION OF CATECHOLAMINES DURING RELATIVE REST AND PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	Adrenaline + noradrenaline							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	15.062	1	15.062	0.098	8.656	1	8.656	0.014
Subj. w.A	2756.289	18	153.127		12344.875	20	617.244	
Within subjects								
B (measurements)	200.015	2	100.007	2.482	693.219	2	346.609	1.770
AB	1.726	2	0.863	0.021	24.875	2	12.438	0.063
B* subj. w.A	1450.164	36	40.282		7835.031	40	195.876	
Total	4423.258				20906.656			
A (adj.)	49.211	1	49.211	0.653	81.086	1	81.086	0.170
Subj. w.A (adj.)	1279.516	17	75.265		9087.502	19	478.289	

Source	Ratio of noradrenaline and adrenaline (NA/A)							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	6.559	1	6.559	0.464	0.995	1	0.995	0.285
Subj. w.A	282.864	20	14.143		69.614	20	3.480	
Within subjects								
B (measurements)	36.608	2	18.304	2.784	1.509	2	0.754	0.797
AB	17.030	2	8.515	1.295	1.254	2	0.627	0.662
B* subj. w.A	263.012	40	6.575		37.875	40	0.946	
Total	606.073				111.249			
A (adj.)	6.294	1	6.294	0.423	3.557	1	3.557	1.320
Subj. w.A (adj.)	282.807	19	14.885		51.193	19	2.694	

* $p < 0.05$
** $p < 0.025$
*** $p < 0.01$
**** $p < 0.001$

TABLE XIX SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON CHANGE IN CATECHOLAMINE EXCRETION FROM RELATIVE REST TO PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	Change in adrenaline (Δ A)				Change in noradrenaline (Δ NA)			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	2.742	1	2.742	0.058	32.609	1	32.609	0.197
Subj. w.A	839.099	18	46.616		2967.961	18	164.886	
Within subjects								
B (measurements)	50.458	2	25.229	1.661	131.058	2	65.529	1.422
AB	20.195	2	10.097	0.664	82.492	2	41.246	0.895
B* subj. w.A	546.763	36	15.187		1657.808	36	46.050	
Total	1459.259				4871.930			
A (adj.)	2.285	1	2.285	0.052	41.583	1	41.583	0.250
Subj. w.A (adj.)	737.129	17	43.360		2816.474	17	165.674	

Source	Change in NA + A (Δ NA + A)			
	SS	df	MS	F
Between subjects				
A (groups)	3.890	1	3.890	0.012
Subj. w.A	5387.047	18	299.280	
Within subjects				
B (measurements)	227.546	2	113.773	1.179
AB	71.156	2	35.578	0.368
B* subj. w.A	3471.312	36	96.425	
Total	9160.955			
A (adj.)	9.145	1	9.145	0.031
Subj. w.A (adj.)	4982.263	17	293.074	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$

TABLE XX SUMMARY OF ANALYSIS OF VARIANCE AND COVARIANCE ON URINARY EXCRETION OF 17 - HYDROXCORTICOSTEROIDS DURING RELATIVE REST AND PHYSICAL WORK DURING A PERIOD OF ENDURANCE TRAINING

Source	17 - OHCS µg/min							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	2.454	1	2.454	0.193	0.610	1	0.610	0.033
Subj. w.A	253.482	20	12.674		359.670	20	17.983	
Within subjects								
B (measurements)	1.672	2	0.836	0.199	2.716	2	1.358	0.191
AB	4.843	2	2.421	0.577	13.368	2	6.684	0.941
B* subj. w.A	167.807	40	4.195		283.882	40	7.097	
Total	430.260				660.249			
A (adj.)	2.147	1	2.147	0.161	0.598	1	0.598	0.031
Subj. w.A (adj.)	252.668	19	13.298		359.118	19	18.900	

Source	17 - OHCS ng/min/kg of body weight							
	(A) Rest				(B) Period of works I - III			
	SS	df	MS	F	SS	df	MS	F
Between subjects								
A (groups)	0.110	1	0.110	0.403	0.029	1	0.029	0.85
Subj. w.A	5.487	20	0.274		6.957	20	0.347	
Within subjects								
B (measurements)	0.009	2	0.004	0.049	0.049	2	0.024	0.159
AB	0.033	2	0.016	0.169	0.331	2	0.165	1.064
B* subj. w.A	3.943	40	0.098		6.219	40	0.155	
Total	9.584				13.586			
A (adj.)	0.120	1	0.120	0.421	0.029	1	0.029	0.080
Subj. w.A (adj.)	5.432	19	0.285		6.893	19	0.362	

* $p < .05$
** $p < .025$
*** $p < .01$
**** $p < .001$