Psychology
2013. Vol.4, No.7, 613-618
Published Online July 2013 in SciRes (http://www.scirp.org/journal/psych)
Scientific Research
DOI:10.4236/psych.2013.47087

# Elite Sport and Biological Age

## Influence of Extensive or Regular Low to Moderate Exercise on Plasma DHEA-S and Cortisol in Ice-Hockey Players

Benny Johansson[1], Lars-Eric Uneståhl[2]
[1]Scandinavian International University, Örebro, Sweden
[2]Örebro University, Örebro, Sweden
Email: info@siu.nu, benny@akloma.com

Received April 21st, 2013; revised May 23rd, 2013; accepted June 22nd, 2013



Based on common comments that elite players in soccer and ice-hockey often looked "older" than non-players of the same age, the authors examined the research literature but found that very few studies had been conducted in the area of elite sport and biological age. We therefore decided to conduct a pilot study comparing professional elite ice hockey players (EP) (22 males, M = 24.7 years) with a cohort of amateur players (AP) similar in age but from a lower competitive level (17 males, M = 25.4 years). Subjective ratings of motivational, attitude and emotional factors were combined with measurements of blood concentrations of DHEA-S, cortisol and the DHEA-S/cortisol ratio. DHEA-S and the DHEA-S/cortisol ratio were significantly higher ($p < 0.01$) while cortisol was unaffected in the AP compared with the EP group. Interpretation of the differences in adrenal hormones level indicated a biological age difference of around 10 years, with the EP group being older. Also, significant differences in the subjective ratings were noted with a more positive self-image, goal-image, attitude and emotions noted in the AP-group. As we have earlier demonstrated a decrease in biological age with mental training of these factors, further studies have to determine how much the higher biological age among the EP-group is due to exercise factors, experiential/personal factors or a combination of these and other factors.

*Keywords*: Competitive Sport; Biological Age; Stress; Adrenal Hormones; Emotional Factors; Lifestyle

## Hypothesis

The process of biological aging goes faster in elite athletes compared with athletes from a lower level.

If so, the difference in biological age depends on a combination of factors, of which two have been investigated in this study:

1) The frequency and intensity of the physical training (physical stress);

2) How differences in physical and mental stress levels effect psychological and personality dimensions with relations to biological age.

## Introduction

Many studies have been conducted to determine the health effects of physical exercise and competitive sport (Blair, Cheng, & Holder, 2001; Kriska, Saremi, Hanson, Bennett, Kobes, Williams, & Knowler, 2003; Pate, Pratt, Blair, Haskell, Macera, Bouchard, Buchner, Ettinger, Heath, King, Kriska, Leon, Marcus, Morris, Paffenbarger, Patrick, Pollock, Rippe, Sallis, & Wilmore, 1995; Fogelholm, Kaprio, & Sarna, 1994; Haskell, Lee, Pate, Powell, Blair, Franklin, Macera, Heath, Thompson, & Bauman, 2007), but the "dose-response" as well as type, optimal intensity and duration of exercise for wellbeing and good health remains unclear (Blair, LaMonte, & Nichman, 2004; Kesaniemi, Danforth, Jensen, Kopelman, Lefebvre, & Reeder, 2001). Statistics of longevity of elite athletes from sport have been difficult to find and the few found show conflicting results (Schnor, 1971; Schnor, 1972; Kujala, Tikkanen, Sarna, Pukkala, Kaprio, & Koskenvou, 2001; Kujala, 2005; Paffenbarger, Hyde, Wing, & Hsieh, 1986; Sanchis-Gomar, Olaso-Gonzales, Corella, Gomez-Cabrera, & Vina, 2011). Several studies confirm that physical and cardiorespiratory fitness and healthy life style factors contribute to increased average longevity even at long-term strenuous exercise (Fogelholm, Kaprio, & Sarna, 1994; Sanchis-Gomar, Olaso-Gonzales, Corella, Gomez-Cabrera, & Vina, 2011; Lee, Artero, Sui, & Blair, 2010). One explanation of the contradictory results could be that the relation between health levels and competitive sport levels may be described as an inverted U-form relation, where too little and too much may lower health levels compared with a moderate level.

Physical exercise and the influence of emotional and psychological stress are significant stimuli of the endocrine system. The hypothalamus, pituitary and adrenal glands (HPA-axis) play a central role in the body's adaptation to stress-related responses (Faredin, Fazekas, Toth, & Juslesz, 1969; Parker, Eugene, Farber, Lifrak, Lai, & Juler, 1985). The typical hormone stressors are of physical, emotional, psychological and infectious nature depending on type, intensity, and duration of the stressor and individual characteristics (Endoh, Kristiansen, Casson, Buster, & Hornsby, 1996). The hormonal response to physical exercise depends on several external factors, e.g. intensity, duration and mode of exercise (Galbo, Hummer, Petersen, Christensen, & Bie, 1977; Sutton, Coleman, Casey, & Lazarus, 1973; Trembaly, Copeland, & Van Helder, 2004). The regulative response of the HPA-axis towards environmental changes and challenges also involves perceptual and cognitive experiences (Endoh, Kristiansen, Casson, Buster, & Hornsby, 1996).

The most important and abundant stress hormone is cortisol (Parker, Eugene, Farber, Lifrak, Lai, & Juler, 1985). The secretion of adrenal cortisol in response to stress activation is in a counteracted manner related to the level of dehydroepiandrosterone sulfate (DHEA-S) (Orentreich, Brind, Rizer, & Vogelman, 1984). The blood concentration of DHEA-S and its primary active analogue dehydroepiandrosterone (DHEA) (Leowattana, 2001) reflects the biological conditions of acute and chronic stress (Kroboth, Salek, Pittenge, Fabian, & Frye, 1999; Boudarene, Legros, & Timsit-Berthier, 2002). Falling concentrations have been observed in both mental and psychological stress and physical illness (Boudarene, Legros, & Timsit-Berthier, 2002). The adrenal secretion and blood concentration follows a biphasic time course during lifetime, peaking in the range of 20 - 30 years (Barrett-Conner, Khaw, & Yen, 1986; Baulieu, 1996; Corrigan, 2002). Thereafter, the blood concentration is declining by a small percentage yearly (Baulieu, 1996; Wisniewski, Hilton, Morse, & Svec, 1993).

Extensive physical load during marathon in male athletes demonstrated that DHEA-S and cortisol were significantly increased (Ponjee, De Rooy, & Vader, 1994). During endurance training, DHEA-S increased in a dose-dependent manner at repeated running sessions for two hours. Cortisol was declined at all running sessions except at two hours, where the response was increased. The ratio of DHEA-S to cortisol was greater at rest and shorter running than at longer runs (Tremblay, Copeland, & Van Helder, 2005). Plasma DHEA was reported to increase with exercise, depending on the level of performance and intensity of the exercise (Cumming & Rebar, 1985; Valaido, Pantaleoni, & Valeiro, 1991). During 24 h running in men, DHEA-S, was increased over the course of 24 h, while falling level in DHEA-S may be possible using continuous aerobic exercise (Shimizu, Imanishi, Sugimoto, Takeda, Hirata, Andou, Morikawa, Suzuki, Watanabe, Okuta, Kawana, Namikawa, Suzuki, Watanabe, Okada, & Oht, 2011). Even though, cortisol was increased, changes in reactive oxygen spices were within normal range and the adaptation for antioxidation was good, indicating low or moderate stress to the body. In marathon runners, lowered cortisol and higher DHEA-S/cortisol ratio correlated with lowered leptin and thus more efficient energy expenditure for the best runners (Bobbert, Mai, Brechtel, Schult, Weger, Pfeiffer, Spranger, & Diederich, 2012). Evaluated from two separate independent studies, the plasma DHEA-S differs by approximately 14% when compared between endurance trained (Tremblay, Copeland, & Van Helder, 2005) and untrained (Nafziger, Bowlin, Jenkins, & Pearson, 1998) men at comparable age (31 years), the extensively trained men being lower at rest. The exercise in the trained men increased the DHEA-S in a dose-response manner with the greatest increase observed during 2 h run, comparable to the normal plasma level in untrained men.

In sportswomen, the ratio of DHEA to cortisol in saliva was increased by more than 30% during a 16 week training program with no difference between highly trained national and moderately trained regional groups. The athletes with the highest performance levels and greatest amount of training showed a less increase in the DHEA/cortisol ratio In contrast, the corresponding ratio was significantly lower in sedentary women (Filaire, Duch, & Lac, 1998). Cortisol did not change with the training over the season and was higher in the elite than in regional women. The training program increased significantly DHEA in all sportswomen.

In non-athletes, increased plasma DHEA-S has been connected with alleviated chronic stress-load (Glaser, Brind, Vogelma, Eisner, Dillbeck, Walace, Chopra, Orentreich, 1992; Arlt, Callies, van Vlijmen, Koehler, Reinecke, Bidlingmaier, Huebler, Oettel, Ernst, Schulte, & Allolio, 1999), positive measures of well-being (Cawodd, & Bancroft, 1996), continued moderate physical activity (Keiser, Kuipers, de Haan, Beckers, & Habets, 1987; Caciarri, Mazzanti, Tassinar, Bergamaschi, Magnani, Zappulla, Nanni, Cobianchi, Ghini, Pini, & Tani, 1990) and repetitive application of stress-reducing and relaxation activities (Glaser, Brind, Vogelma, Eisner, Dillbeck, Walace, Chopra, & Orentreich, 1992; Johansson, & Uneståhl, 2005).

The aim of this study was to compare elite with amateur ice-hockey players on cognitive and emotional issues and on the integrity of the HPA-axis by assessing the level of the adrenal hormones DHEA and cortisol in order to relate this to biological age.

## Subjects and Methods

### Design

The purpose of this study was to monitor the effect of extensive or low to moderate training for two teams of male ice-hockey players, on blood concentrations of DHEA-S and cortisol, the DHEA-S/cortisol ratio and on experiential areas. Subjective data were collected from the SMAE factor questionnaire (Unestahl & Bundzen, 1996), which measures self-image, goal-Images, attitude and emotions.

One team consisted of highly-trained elite players, playing on national level, while the second team was a low to moderate trained regional ice hockey team. In accordance with previous presented research findings, the blood concentration ratio of DHEA-S/cortisol could serve as a biochemical marker and model for the anabolic/catabolic balance in sportsmen (Adlercreuts, Hakonen, Kuoopasalami, Naveri, Huhtanemi, Tikkanen, Remes, Dessypris, & Karvonen, 1986) with relation to biological age and to physiological and psychological well-being (Johansson & Uneståhl, 2005).

### Subjects

A group of 39 healthy male volunteers took part in the study; 22 national and 17 regional ice-hockey players. The Elite Players (EP) had an average age of 24.7 years (19 - 33) and the amateur players (AP) averaged at 25.4 years (17 - 35). The EP group consisted of professional ice-hockey players, whereas the players in the AP group were amateur players with ordinary labour work during daytime. None of the participants were taking medication. Both groups were lead by professional coaches. The study was done during the second part of the winter season. All subjects in the EP group were on daily scheduled individual and team-based extensive training program except on match days and remained unchanged during the study. The training program during non-match days, comprised of two daily sessions of two hours each. Long-distance and exhausting continental bus transfers provided the transportation of the professional team players away from home competitions. Two competition games were performed on regular weekly basis during the season.

The players in the AP group followed a low or moderate training and competition program. Scheduled training was performed twice weekly for two hours and a competition game only once a week. Due to the local character and short-distance of transportation at competitions, co-transportation of team players was done by car. The content of the study protocol followed the recommendations of the local committee of human ethics. Each subject was informed of the test procedures and a written consent was obtained before study start.

## Subjective Measures

Subjective self-reported measurements were made with the Swedish "SMAK" test, measuring the dimension: Self-image (S), Goal-images and Motivation (M), Attitudes (A) and Emotions (K). The Test was developed by Unestahl in the 1970's in cooperation with a number of national teams and the Swedish Olympic Teams 1976 and 1980. It has been used in a number of studies since then, among other in our last study about biological age (Johansson & Uneståhl, 2005). The test has good reliability and validity.

The S-factor (Self-Image) has statements related to Self-confidence as well as Self-esteem. The Goal-Images covers both Goal-level and Motivation. The Attitude scale has statements related to the Optimist—Not Optimist dimension, and also statements about Mental toughness and Resilience. The "E" factor is intended to measure "Internal Success" (transitory feelings of satisfaction, enjoyment, wellbeing and happiness). Changes in the SMAE factors through Mental Training have earlier been related to a number of psychophysiological and neuroimmunological factors (Johansson & Uneståhl, 2005; Unestahl & Bundzen, 1996; Bundzen, Leissner, Malinin, & Unestahl, 1996; Unestahl, Bundzen, Gavrilova, & Isakov, 2004; Bundzen, Gavrilova, Isakov, & Unestahl, 1998).

## Collection of Blood and Analysis of Steroid Hormones

Venous blood samples were collected in the morning in Vacutainer® tubes and 5 ml of blood were drawn for each sample. Blood samples were centrifuged immediately and stored frozen at –20˚C until assayed. All plasma samples were analysed in duplicate at an accredited local hospital department of clinical chemistry, according to standard laboratory methods for DHEA-S and cortisol (Beishuizen, Thijs, & Vermes, 2002; Normile, 1998; Labrie, Bélanger, Cusan , Gomez, & Candaz, 1997).

## Statistical Analysis

All descriptive quantitative data were reported as mean ± SD. Comparisons between groups were made by unpaired student's t-test, while a two-tailed $p$ value < 0.05 was considered as statistical significant.

# Results

Mean plasma DHEA-S, cortisol and the ratio of DHEA-S/cortisol for the EP and AP groups are given in **Figures 1-3**, respectively. The plasma concentration of DHEA-S in the EP group was significantly lower (<0.01) compared to the AP-group (**Figure 1**). The level of plasma cortisol was the same in both groups (**Figure 2**). The ratio of DHEA-S to cortisol was significantly higher in the EP-group compared with the AP group ($p < 0.01$), indicating elevated catabolism in professional players with sustained anabolism in amateurs (**Figure 3**). In the SMAE factor test all personal subjective factors were found to have significantly more positive ratings in the amateurs (AP);

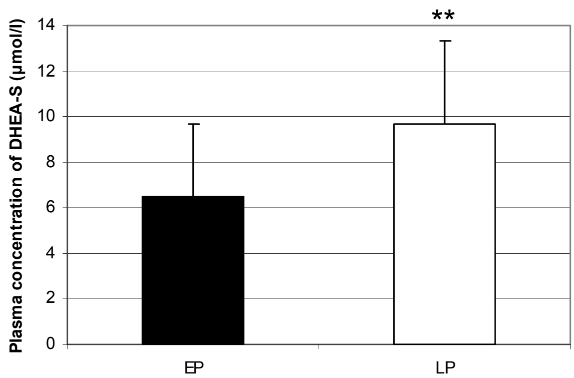


**Figure 1.**
Plasma concentration of DHEA-S (Mean ± SD) in the EP and LP groups ($^{**}p < 0.01$).

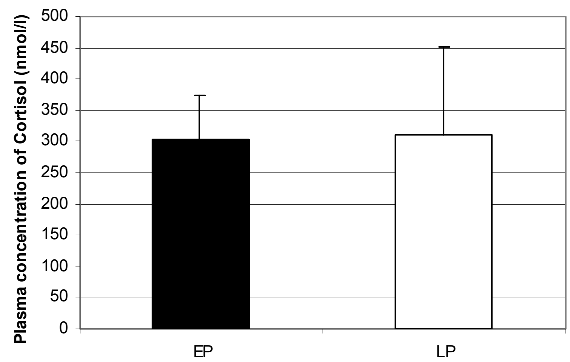


**Figure 2.**
Plasma concentration of cortisol (Mean ± SD) in EP and LP groups.

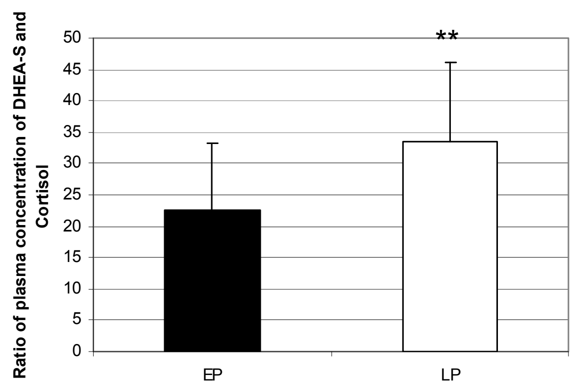


**Figure 3.**
Plasma concentration of the DHEA-S/cortisol ratio (Mean ± SD) in the EP and LP groups ($^{**}p < 0.01$).

Self-image ($p = 0.008$), Goal images ($p = 0.023$), Attitudes ($p = 0.032$), and Emotions ($p < 0.001$) (**Table 1**). Thus, in professionals the response of the HPA-axis followed the level of physical exercise reflected in a concomitant emotional and cognitive stress load.

## Discussion

The 33% higher plasma DHEA-S in the AP group corresponds to a difference in biological age that according to normal reference observations is approximately 10 years below the average age range in the EP-group. The subjective ratings showed that the amateur ice-hockey players (AP) had significantly better self-images, were more goal-oriented and motivated, were interpreting life in a more positive way and had more of positive emotions. Whether, the difference in biological age was mainly due to exercise levels or cognitive and emotional factors or a combination of these cannot be directly determined based on this study. We know from an earlier study (Johansson & Uneståhl, 2005) that mental training of cognitive and emotional factors can raise the DHEA-S/Cortisol ratio (thus suggesting a lowering of the biological age). We also know from a previous study (Unestahl, Bundzen, Gavrilova, & Isakov, 2004) that systematic mental training can increase the tolerance for hard training and prevent the negative effects of "overtraining", partly due to improved rest and recovery skills. Thus, one contributing explanation of the results of our study could be that the lower intensity of training and matches in the amateur players gave them more time for rest and recover. The plasma DHEA-S and DHEA-S to cortisol ratio were concomitantly higher in the AP group, in spite of no difference in the plasma cortisol between groups.

Thus, the lower DHEA-S and the lower DHEA-S to cortisol ratio together with less positive subjective emotional experiences among the elite players, agrees with the negative influence of lowered levels of these hormones on both psychological and physiological, physical performance and health outcome (Endoh, Kristiansen, Casson, Buster, & Hornsby, 1996).

Since the HPA axis is influenced by psychological, emotional or physical stress (Faredin, Fazekas, Toth, & Juslesz, 1969; Parker, Eugene, Farber, Lifrak, Lai, & Juler, 1985; Duran-Bush, Faubert, & Newburg, 2004); Singh, Petrides, Gold, Chrousos, & Deuster, 1999), DHEA-S has been identified as an anti-stress hormone related to the antagonistic action towards cortisol (Boudarene, Legros, & Timsit-Berthier, 2002). The counteracting inter-balanced secretion towards stress and anxiety of the most numerous androgen DHEA-S has been a suggested force on experience of the positive feeling of wellbeing (Orentreich, Brind, Rizer, & Vogelman, 1984, Boudarene, Legros, & Timsit-Berthier, 2002; Normile, 1998). Tentatively, DHEA-S is involved in conditioning of an emotional state based not only on improved wellbeing and external success(Glaser, Brind, Vogelma, Eisner, Dillbeck, Walace, Chopra, Orentreich, 1992; Cawodd & Bancroft, 1996; Johansson & Uneståhl, 2005), but a shift in personal traits aligned with a comfortable attitude towards life-experiences and events built on high emotional internal self-residence.

**Table 1.**
SMAE personal trait factors in ice-hockey players.

| | Goal-image* | Self-image'** | Attitude*** | Emotion# |
|---|---|---|---|---|
| Amateurs | 2.9 ± 0.5 | 2.2 ± 0.4 | 2.1 ± 0.4 | 1.9 ± 0.4 |
| Professionals | 2.4 ± 0.5 | 1.9 ± 0.35 | 1.7 ± 0.4 | 1.6 ± 0.5 |

Note: $^{*}p = 0.008$; $^{**}p = 0.024$; $^{***}p = 0.032$; $^{\#}p = 0.001$.

The results indicate that the amateurs are more adapted to a resonance state in a process that allows the individuals to feel the way they want to feel. Such a state of self-development underlies how to make meaning of daily experiences, and is reflected in the success of planning, thinking, and acting (Loevinger, 1976; Loevinge, Cohn, Bonneville, Redmore, Streich, Bonneville, Redmore, Streich, & Sargent, 1985; Cook-Greuter, 1999). The process is typically experienced as a seamless fit or harmony between the individual and the environment (Duran-Bush, Faubert, & Newburg, 2004).

The unchanged plasma cortisol between groups at restful conditions in the morning before the daily physical exercise begun accompanied with the decrease in the DHEA-S/cortisol ratio in professionals, agrees with findings after moderate physical exercise, which even lead to an increase in plasma cortisol when the exercise was intensified (Adlercreuts, Hakonen, Kuoopasalami, Naveri, Huhtanemi, Tikkanen, Remes, Dessypris, & Karvonen, 1986; Trembaly, Copeland, & Van Helder, 2004). Prolonged over-intense training may lead to an over-strained condition, which may involve mental exhaustion, emotional discomfort and hormonal disturbance in the balance between anabolic and catabolic hormones. Continuing the physical training with unchanged intensity will in such a case have negative effects on physical performance (Adlercreuts, Hakonen, Kuoopasalami, Naveri, Huhtanemi, Tikkanen, Remes, Dessypris, & Karvonen, 1986). A study monitoring over-strain in two groups of long-distance runners, identified physiological over-strain from the plasma testosterone/cortisol ratio when it was exceeding 30% (Adlercreuts, Hakonen, Kuoopasalami, Naveri, Huhtanemi, Tikkanen, Remes, Dessypris, & Karvonen, 1986). Besides testosterone, other anabolic hormones have been tested monitoring physical overstrain (Adlercreuts, Hakonen, Kuoopasalami, Naveri, Huhtanemi, Tikkanen, Remes, Dessypris, & Karvonen, 1986).

In this regime, DHEA-S is a precursor hormone of more potent androgens involved to restore the consequences of catabolic activity and processes (Nafziger, Bowlin, Jenkins, & Pearson, 1998). Since DHEA-S is also a balancing hormone counteracting on the alleviated secretion of cortisol, e.g. after induction of an physiological state impressed by emotional comfort and well-being (Glaser, Brind, Vogelma, Eisner, Dillbeck, Walace, Chopra, & Orentreich, 1992; Johansson & Uneståhl, 2005**)**, the DHEA-S/cortisol ratio has been used following the physical load in athletes (Ponjee, De Rooy, & Vader, 1994; Trembaly, Copeland, & Van Helder, 2005; Filaire, Duch, & Lac, 1998). The significant difference in DHEA-S/cortisol ratio (32.7%) between the two groups in our study was strongly aliened with the lower rating in especially the subjective emotional measurement in professional ice-hockey players, that may highlight not only the negative influence of professional and elite sports on performance, but the risk of future ill-health (Endoh, Kristiansen, Casson, Buster, & Hornsby, 1996).

The age-dependence of plasma DHEA-S and its precursor DHEA, and the proposed preventive and anti-aging effects including their role as biomarkers of physiological aging has been debated and questioned (Kroboth, Salek, Pittenge, Fabian, & Frye, 1999; Shimizu, Imanishi, Sugimoto, Takeda, Hirata, Andou, Morikawa, Suzuki, Watanabe, Okuta, Kawana, Namikawa, Suzuki, Watanabe, Okada, & Oht, 2011). Studies have shown that stress and serious disease are associated with a shift from secretion of androgens towards glucocorticoids (Cook-Greuter, 2000). This can mainly be seen as increased plasma cortisol and lower DHEA-S (Corrigan, 2002).

Additionally, a decrease in the DHEA/cortisol ratio and low DHEA-S has been correlated with the suppression of cellular immunity and the severity of disease (Parker & Odell, 1980). The average age-dependent decline in plasma DHEA-S concentrations differed significantly by a few % per year by sex and age group (Baulieu, 1996; Wisniewski, Hilton, Morse, & Svec, 1993; Nafziger, Bowlin, Jenkins, & Pearson, 1998). The falling concentration in DHEA-S related to level of mental and physiological stress and physical illness (Boudarene, Legros, & Timsit-Berthier, 2002) support the hypothesis that those subjects with lower DHEA-S has a shorter life-span (Baulieu, 1996).

A common belief with so far limited support by research, is that elite athletes especially elite players in team sports, have a shorter life span than other human beings (Ruiz, Moran, Arenas, & Lucia, 2010). The thrifty of longevity research show conflicting results, where long-distance runners and cross-country skiers (Kujala, Tikkanen, Sarna, Pukkala, Kaprio, & Koskenvou, 2001; Kujala, 2005) and Tour de France cyclists (Sanchis-Gomar, Olaso-Gonzales, Corella, Gomez-Cabrera, & Vina, 2011) had increased longevity, while individuals with weekly energy expenditure in the range of 3500 kcal show a mortality rate higher than the sedentary population (Paffenbarger, Hyde, Wing, & Hsieh, 1986). A less effective energy expenditure gains a stress induced anabolic hormonal response with increased leptin values in over-strain athletes (Bobbert, Mai, Brechtel, Schult, Weger, Pfeiffer, Spranger, & Diederich, 2012r), a plausible longevity risk factor.

## Conclusion

In conclusion our findings indicate that the lower DHEA-S level and DHEA-S/Cortisol ratio among the professional elite players correspond to a biological age around 10 years older than the amateur players. In addition to that the amateur ice hockey players rated themselves as more confident, goal-orientated, motivated and optimistic and with more positive moods and feelings than the professionals. Whether these experiential differences are a result mainly from the training levels or hormonal differences should be investigated in future research.

Other proposals for further research besides doing similar investigations as ours in other sport, (team- and individual-sports) could be to investigate the longevity of athletes in different sports and from different levels of physical activity and psychological distress.

## REFERENCES


Adlercreuts, H., Hakonen, M., Kuoopasalami, K., Naveri, H., Huhtanemi, H., Tikkanen, H., Remes, K., Dessypris, A., & Karvonen, J. (1986). Effect of training on plasma anabolic and catabolic steroid hormones and their responses during physical exercise. *International Journal of Sports Medicine, 7,* S27-S28. doi:10.1055/s-2008-1025798

Arl, W., Callies, F., van Vlijmen, J. C., Koehler, I., Reinecke, M., Bidlingmaier, M., Huebler, D., Oettel, M., Ernst, M., Schulte, H. M., & Allolio, B. (1999). Dehydroepiandrosterone replacement in women with adrenal insufficiency. *The New England Journal of Medicine, 341,* 1013-1020. doi:10.1056/NEJM199909303411401

Barrett-Conner, E., Khaw, K.-T., & Yen, S. (1986). A prospective study of dehydroepiandrosterone sulphate mortality and cardiovascular disease. *The New England Journal of Medicine, 315,* 1519-1524. doi:10.1056/NEJM198612113152405

Baulieu, E.-E. (1996). Dehydroepiandrosterone (DHEA): A fountain of youth. *The Journal of Clinical Endocrinology & Metabolism, 81,* 3147-3151. doi:10.1210/jc.81.9.3147

Beishuizen, A., Thijs, L.G., & Vermes. I. (2002). Decreased levels of dehydroepiandrosteone sulphate in severe critical illness: A sign of exhausted adrenal reserve. *Critical Care, 6,* 434-443. doi:10.1186/cc1530

Blair, S. N., Cheng, Y., & Holder, J. S. (2001). Is physical activity or physical fitness more important in defining health benefits? *Medicine & Science in Sports & Exercise, 33,* S379-S399. doi:10.1097/00005768-200106001-00007

Blair, S. N., LaMonte, M. J., & Nichman, M. Z. (2004). The evolution of physical activityrecommendations: how much is enough? *The American Journal of Clinical Nutrition, 79,* 913S-920S.

Bobbert, T., Mai, K., Brechtel, L., Schult, H. M., Weger, B., Pfeiffer, A. F., Spranger, J., & Diederich, S. (2012). Leptin and endocrine parameters in marathon runners. *International Journal of Sports Medicine, 33,* 244-248. doi:10.1055/s-0031-1291251

Boudarene, M., Legros, J. J., & Timsit-Berthier, M. (2002). Study of stress response: Role of anxiety, cortisol DHEAs. *Encephale, 28,* 139-146.

Bundzen, P., Gavrilova, E., Isakov, V., & Unestahl, L. E. (1998). Stresslimiting and immunomodulating effect of mental training. *Pathophysiology, 5,* 148. doi:10.1016/S0928-4680(98)80865-1

Bundzen, P., Leissner, P., Malinin, A., & Unestahl, L. E. (1996). Mental relaxation: Neuro-dynamic markers and psychophysiological mechanisms. In: R. Rodano, & D. Hill (Eds.), *Current research in sport sciences: An international perspective* (pp. 91-101). New York and London: Plenum Press. doi:10.1007/978-1-4757-2510-0_15

Caciarri, E., Mazzanti, L., Tassinari, D., Bergamaschi, R., Magnani, C., Zappulla, F., Nanni, G., Cobianchi, C., Ghini, T., Pini, R., & Tani, G. (1990). Effects of sport (football) on groth: Auxological, antropometric and hormonal aspects. *European Journal of Applied Physiology, 61,* 149-158. doi:10.1007/BF00236710

Cawodd, E. H. H., & Bancroft, J. (1996). Steroid hormones, the menopause, sexuality and well-being of women. *Psychological Medicine, 26,* 925-936. doi:10.1017/S0033291700035261

Cook-Greuter, S. (1999). Postautonomous ego development: Its nature and measurement. Doctoral Dissertation, Harvard: Harvard Graduate School of Education.

Cook-Greuter, S. (2000). Mature ego development: A gateway to ego transcendence? *Journal of Adult Development, 7,* 227-240. doi:10.1023/A:1009511411421

Corrigan, B. (2002). DHEA and sport. *Clinical Journal of Sport Medicine, 12,* 236-241. doi:10.1097/00042752-200207000-00006

Cumming, D., & Rebar, R. W. (1985). Hormonal changes with acute exercise and with training in women. *Seminars in Reproductive Endocrinology, 3,* 55-64. doi:10.1055/s-2007-1022604

Duran-Bush, N., Faubert, C., & Newburg, D. (2004). Achieving optimal performance and well-being through resonance. *Svensk Idrottsförenings Årsbok*, 1-24.

Endoh, A., Kristiansen, S. B., Casson, P. R., Buster, J. E., & Hornsby, P. J. (1996). The zona reticularis is the site of biosynthesis of dehydroepinandrosterone and dehydroepinandrosterone sulfate in the adult adrenal cortex resulting from its low expression of 3β-hydroxysteroid dehydrogenase. *The Journal of Clinical Endocrinology & Metabolism, 81,* 3558-3565. doi:10.1210/jc.81.10.3558

Faredin, I., Fazekas, A., Toth, I., & Juslesz, M. (1969). Transformation *in vito* of (4-$^{14}$C)dehydroepiandrosterone into 7-oxygenated derivatives by the normal human male and female skin tissue. *Journal of Investigative Dermatology, 52,* 357-361.

Filaire, E., Duché, P., & Lac, G. (1998). Effects of amount of training on the saliva concentrations of cortisol, dehydrooepiandrosterone and the dehydroepiandrosterone: Cortisol concentration ratio in women over 16 weeks of training. *European Journal of Applied Physiology, 78,* 466-471. doi:10.1007/s004210050447


 

Fogelholm, F., Kaprio, J., & Sarna, S. (1994). Healthy lifestyles of former Finnish world class athletes. *Medicine & Science in Sports & Exercise, 26,* 224-229. doi:10.1249/00005768-199402000-00013

Galbo, H., Hummer, L., Petersen, B., Christensen, N. J., & Bie, N. (1977). Thyroid and testicular hormone responses to graded and prolonged exercise in man. *European Journal of Applied Physiology, 36,* 101-106. doi:10.1007/BF00423117

Glaser, J. L., Brind, J. L., Vogelman, J. H., Eisner, M. J., Dillbeck, M. C., Walace, R. K., Chopra, D., & Orentreich, N. (1992). Elevated serum dehydroepiandrosterone sulfate levels in practitioners of the transcendental meditation (TM) and TM-sidhi programs. *Journal of Behavioural Medicine, 15,* 327-341. doi:10.1007/BF00844726

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., Macera, C. A., Heath, G. E., Thompson, P. D., & Bauman, A. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sport Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise, 39,* 1423-1434. doi:10.1249/mss.0b013e3180616b27

Johansson, B., & Uneståhl, L.-E. (2006). Stress reducing regulative effects of integrated mental training with self-hypnosis on the secretion of dehydroepiandrosterone sulfate (DHEA-S) and cortisol in plasma. A pilot study. *Contemporary Hypnosis, 23,* 101-110. doi:10.1002/ch.314

Keiser, H. A., Kuipers, H., de Haan, J., Beckers, E., & Habets, L. (1987). Multiple hormonal responses to physical exercise in eumenorrheic trained and untrained women. *International Journal of Sports Medicine, 8,* 139-150.

Kesaniemi, Y. K., Danforth Jr., E Jensen, M. D., Kopelman, P. G., Lefebvre, O., & Reeder B. A. (2001). Dose-response issues concerning physical activity and health. An evidence-based symposium. *Medicine & Science in Sports & Exercise, 33,* S351-S358. doi:10.1097/00005768-200106001-00003

Kriska, A. M., Saremi, A., Hanson, R. L., Bennett, P. H., Kobes, S., Williams, D. E., & Knowler, W. C. (2003). Physical activity, obesity, and the incidence of type 2 diabetes in high risk population. *American Journal of Epidemiology, 158,* 669-675. doi:10.1093/aje/kwg191

Kroboth, P. D., Salek, F. S., Pittenger, A. L., Fabian, T. J., & Frye, R. F. (2001). DHEA and DHEA-S: A review. *The Journal of Clinical Pharmacology, 39,* 327-348. doi:10.1177/00912709922007903

Kujala, U. M. (2005). Essay: Does training adversely affect long-term health? *Lancet, 366,* S55-S56. doi:10.1016/S0140-6736(05)67853-1

Kujala, U. M., Tikkanen, H. O., Sarna, S., Pukkala, E., Kaprio, J., & Koskenvou, M. (2001). Disease-specific mortality among elite athletes. *JAMA, 285,* 44-45. doi:10.1001/jama.285.1.44

Labrie, F., Bélanger, A., Cusan, L., Gomez, J.-L., & Candaz, B. (1997). Marked decline in serum concentrations of adrenal $C_{19}$ sex steroid precursors and conjugated androgen metabolites during aging. *The Journal of Clinical Endocrinology & Metabolism, 82,* 2396-2402.

Lee, D. C., Artero, E. G., Sui, X., & Blair, S. N. (2010). Mortality trends in the general population: the importance of cardiorespiratory fitness. *Psychopharmacology, 24,* 27-35. doi:10.1177/1359786810382057

Leowattana, W. (2001). DHEA(S): The fountain of youth. *Journal of the Medical Association of Thailand, 84,* S605-S612.

Loevinge, J., Cohn, L. D., Bonneville, L. P., Redmore, C. D., Streich, D. D., Bonneville, L. P., Redmore, C. D., Streich, D. D., & Sargent, M. (1985). Ego development in college. *Journal of Personality and Social Psychology, 48,* 947-962. doi:10.1037/0022-3514.48.4.947

Loevinger, J. (1976). Ego development: Conceptions and theories. San Fransisco: Jossey-Bass.

Nafziger, A. N., Bowlin, S. J., Jenkins, P. L., & Pearson, T. A. (1998). Longitudinal changes in dehydroepinandrosterone concentrations in men and women. *Journal of Laboratory and Clinical Medicine, 131,* 316-323.

Normile, D. (1998). Habitat seen playing larger role in shaping behavior. *Science, 279,* 1454-1455. doi:10.1126/science.279.5356.1454

Orentreich, N., Brind, J. L., Rizer, R. L., & Vogelman, J. H. (1984). Age changes and sex differences in serum dehydroepiandrosterone sulfate concentrations throughout adulthood. *The Journal of Clinical Endocrinology & Metabolism, 59,* 551-555. doi:10.1210/jcem-59-3-551

Paffenbarger Jr., R. S. Hyde, R. T., Wing, A. L., & Hsieh, C. C. (1986). Physical activity, all-cause mortality, and longevity of college alumni. *The New England Journal of Medicine, 314,* 605-613. doi:10.1056/NEJM198603063141003

Parker, L., Eugene, J., Farber, D., Lifrak, E., Lai, M., & Juler, G. (1985). Dissociation of adrenal androgen and cortisol levels in acute stress. *Hormone and Metabolic Research, 17,* 209-212. doi:10.1055/s-2007-1013493

Parker, L. N., & Odell, W. D. (1980). Control of adrenal androgen secretion. *Endocrine Review, 392,* 409. doi:10.1210/edrv-1-4-392

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W., King, A. C., Kriska, A., Leon, A. S., Marcus, B. H., Morris, J., Paffenbarger, R. S., Patrick, K., Pollock, M. L., Rippe, J. M., Sallis, J., & Wilmore, J. H. (1995). Physical activity and public health. A recommendation from the centers for disease control and prevention and American college of sport medicine. *JAMA, 273,* 402-407. doi:10.1001/jama.1995.03520290054029

Ponjee, G. A., De Rooy, H. A., & Vader, H. L. (1994). Androgen turnover during marathon running. *Medicine & Science in Sports & Exercise, 26,* 1274-1277. doi:10.1249/00005768-199410000-00015

Ruiz J. R., Moran, M., Arenas, J., & Lucia, A. (2010). Strenous endurance exercise impoves life expectancy: It's in our genes. British *Journal of Sports Medicine, 45,* 159-161. doi:1136/bjsm.2010.075085

Sanchis-Gomar, F., Olaso-Gonzales, G., Corella, D., Gomez-Cabrera, M. C., & Vina, J. (2011). Increased average longevity among the "Tour de France" cyclists. *International Journal of Sports Medicine, 32,* 644-647. doi:10.1055/s-0031-1271711

Schnohr, P. (1971). Longevity and causes of death in male athletic champions. *Lancet, 2,* 1364-1366. doi:10.1016/S0140-6736(71)92377-4

Schnohr, P. (1972). Athletic activity and longevity. *Lancet, 2,* 605. doi:10.1016/S0140-6736(72)92007-7

Shimizu, T., Imanishi, A., Sugimoto, K., Takeda, N., Hirata, N., Andou, T., Morikawa, S., Suzuki, Y., Watanabe, M., Okuta, M., Kawana, T., Namikawa, Y., Suzuki, M., Watanabe, M., Okada, T., & Oht, M. (2011). Sequential changes in inflammatory and stress responses during 24-hour running. *Rinsho Buori, 59,* 930-935.

Singh, A., Petrides, J. S., Gold, P. W., Chrousos, G. P., & Deuster, P. A. (1999). Differential hypothalamic-pituitary-adrenal axis reactivity to psychological and physical stress. *The Journal of Clinical Endocrinology & Metabolism, 84,* 1944-1948.

Sutton, J., Coleman, M., Casey, J., & Lazarus, L. (1973). Androgen responses during physical exercise. *British Medical Journal, 1,* 520-522. doi:10.1136/bmj.1.5852.520

Trembaly, M. S., Copeland, J. L., & Van Helder, W. (2004). Effect of training status and exercise mode on endogenous steroid hormones in men. *Journal of Applied Physiology, 96,* 531-539. doi:10.1152/japplphysiol.00656.2003

Tremblay, M. S., Copeland, J. L., & Van Helder, W. (2005). Influence of exercise duration on post-exercise steroid hormone responses in trained males. *European Journal of Applied Physiology, 94,* 505-513.

Unestahl, L. E., & Bundzen, P. (1996). Integrated Mental Training—Neuro-biochemical mechanisms and psycho-physical consequences. *Hypnotherapy, 23,* 148-156.

Unestahl, L.-E., Bundzen, P., Gavrilova, E., & Isakov, V. (2004). The effects of integrated mental training on stress and psychosomatic health. *Hypnotherapy, 31,* 83-88.

Valaido, A., Pantaleoni, M., & Valeiro, L. (1991). Influence of exercise on dehydroepiandrosterone sulphate and delta 4 androstenedione plasma levels in man. *Experimental and Clinical Endocrinology & Diabetes, 97,* 99-101. doi:10.1055/s-0029-1211046

Wisniewski, T. L., Hilton, C. W., Morse, E. V., & Svec, F. (1993). The relationship of serum DHEA-S and cortisol levels to measures of immune function in human immuno-deficiency virus-related illness. *The American Journal of the Medical Sciences, 305,* 379-465. doi:10.1097/00000441-199302000-00003