

UC Irvine

UC Irvine Previously Published Works

Title

The GH-IGF-I response to typical field sports practices in adolescent athletes: a summary.

Permalink

<https://escholarship.org/uc/item/63x974pj>

Journal

Pediatric Exercise Science, 26(4)

ISSN

0899-8493

Authors

Eliakim, Alon
Cooper, Dan M
Nemet, Dan

Publication Date

2014-11-01

DOI

10.1123/pes.2014-0159

Peer reviewed

The GH-IGF-I Response to Typical Field Sports Practices in Adolescent Athletes: A Summary

Alon Eliakim

Tel Aviv University

Dan M. Cooper

University of California, Irvine

Dan Nemet

Tel Aviv University

The present study compares previous reports on the effect of “real-life” typical field individual (ie, cross-country running and wrestling—representing combat versus noncombat sports) and team sports (ie, volleyball and water polo—representing water and land team sports) training on GH and IGF-1, the main growth factors of the GH→IGF axis, in male and female late pubertal athletes. Cross-country running practice and volleyball practice in both males and females were associated with significant increases of circulating GH levels, while none of the practices led to a significant increase in IGF-I levels. The magnitude (percent change) of the GH response to the different practices was determined mainly by preexercise GH levels. There was no difference in the training-associated GH response between individual and team sports practices. The GH response to the different typical practices was not influenced by the practice-associated lactate change. Further studies are needed to better understand the effect of real-life typical training in prepubertal and adolescent athletes and their role in exercise adaptations.

Keywords: growth hormone, field exercise, adolescents

The growth hormone–insulin-like growth factor-I (GH@IGF-I) axis is composed of hormones, growth factors, binding proteins (BP) and receptors that regulate essential growth, development, metabolic and reparative processes. It is now well established that adaptations of the GH→IGF-I axis also mediate many of the exercise-associated anabolic effects (6). Recent studies suggest that exercise-induced changes in these anabolic hormones can be used by adolescent athletes and their coaches to optimize training (6,11). Interestingly, previous studies have shown that exercise may lead to simultaneous increase of antagonistic mediators, and stimulate both anabolic components of the GH→IGF-I axis (8,11), and catabolic proinflammatory cytokines (12,15,16). It was suggested that the very fine balance between the

exercise-associated anabolic and catabolic response will dictate the effectiveness of training. Dominance of the anabolic response will probably lead ultimately to increased muscle mass and improved fitness, while prolonged catabolic response dominance, in particularly if combined with inadequate nutrition, may lead to overuse injuries and overtraining (7).

The majority of previous studies examined the effects of laboratory-setting endurance-type exercise on the GH→IGF-I axis. These studies suggested that to stimulate GH secretion, the exercise input should be sufficient to cause a sizeable metabolic effect (eg, more than 10 min above the lactic anaerobic threshold; 5). Interestingly, very few studies examined the GH→IGF response to real-life exercise training in individual, and in particularly, in team sports among adolescent athletes. These responses may be especially important in adolescence, since puberty itself is characterized by rapid linear growth, muscle mass gain, and spontaneous spurt of anabolic hormones. Therefore, the aim of the current study was to compare the effect of typical “real life” individual (ie, cross-country and wrestling) and team

Eliakim and Nemet are with the Child Health & Sport Center, Pediatric Dept., Meir Medical Center, Tel Aviv University, Kfar Saba, Israel. Cooper is with the Pediatric Exercise Research Center, University of California, Irvine, CA. Address author correspondence to [Alon Eliakim at eliakim@zahav.net.il](mailto:Alon.Eliakim@zahav.net.il).

(ie, volleyball and water polo) sports training on GH and IGF, the key growth factors of the GH→IGF axis, in male and female late pubertal athletes. In addition, we determined training-associated changes in lactate levels, a commonly used marker of training intensity.

Methods

We reviewed and reanalyzed our previous studies (9,13,14,16) on the hormonal and inflammatory responses to typical field practices in individual and team sports among late pubertal male and female athletes focusing on the GH and IGF-I response. Characteristics of the participants and a brief description of the typical different practices are described below:

Cross-Country

Eight elite female cross-country runners (mean age 16.75 ± 0.5 years, age range 15–18 years, Tanner stage for pubic hair 5) participated in the study. Participants were members of the university high-school cross-country team and trained for 8–12 hr per week.

Training Protocol. Warm-up (10 min)—a low intensity jog, followed by lower and upper body stretches. Continuous run (40–50 min)—the main workout consisted of 40–50 min of high-intensity running throughout the UCI Campus. The girls were motivated to continue running “all out” throughout the practice. Participants performed 10 min cool-down at the end of the practice.

Wrestling

Eleven elite male wrestlers (mean age 16.5 ± 0.5 years, age range 14–18.5 years, Tanner stage for pubic hair 4–5) participated in the study. Participants were members of the university high-school wrestling team and trained for 8–12 hr per week.

Training Protocol. Warm-up (15 min): Jogging, stretch exercise with sports-specific calisthenics such as push-ups and sit-ups. Technique Drills (15 min): The subjects performed typical wrestling skills including takedowns, escapes, pin combinations, and pin counters. The technique drills involved high-intensity exercise of short duration (6–10 s). Situation wrestling (15 min): The subjects were paired or placed in groups of 3. Specific wrestling positions were assigned, and subjects wrestled from the given situation practicing a specific move and its counters. This involved exercise at maximal effort in bursts of 15–20 s (*iron man*; 15 min): Wrestlers were placed in groups of 5 or 6 with 1 wrestler in each group designated the iron man. The iron man continuously wrestled facing a new partner every 30 s. Designation of “iron man” rotated after about 3–4 min. Each wrestler was the iron man at least once during this drill. Live Wrestling (10 min): Each wrestler was paired with a partner of similar weight and ability. Each pair wrestled a full 6-min match. Cool-down (10 min).

Volleyball

Twenty-seven (14 males, mean age 16.3 ± 1.1 years, 13 females, mean age 16.0 ± 0.4 years) healthy elite, national team level Israeli junior volleyball players (age range 13.5–18 years, Tanner stage for pubic hair 4–5) participated in the study. All participants trained for 18–22 hr per week, played in the Israeli premier junior volleyball league, belonged to the Israeli national junior volleyball team, and were members of the Israeli National Academy for Gifted Athletes.

Training Protocol. Each participant performed a typical 1 hr volleyball practice. Training consisted of 20 min dynamic warm-up which included jogging, stretching and running drills at submaximal speed (up to 80% of maximal speed), and additional 20 min of volleyball drills. The main part of the practice included 7 repetitions of 7 consecutive sprints from the back of the volleyball court to the net, maximal jump and a hit of the volleyball over the net in the end of each sprint. Each repetition lasted about 1.5 min with 1 min rest to collect the balls between repetitions.

Water Polo

Ten elite female water polo players (mean age 15.1 ± 0.3 years, age range 14–16 years, Tanner stage for pubic hair 5) participated in the study. Participants were members of the University high-school water polo team and trained for 8–12 hr per week.

Training Protocol. Training consisted of 20 min dry land and swimming warm-up. Twenty minutes of swimming conditioning including 10 min of high intensity drills. Fifteen minutes of leg drills (treading water, and leg swimming up and down the pool), 30 min of shooting (high intensity short swimming burst, vertical/horizontal water position change, and shooting the ball to the goal), passing (between partners at increasing distances) and game drills (mimicking real game situations), and 5 min of cool-down.

GH and IGF-I levels in the different studies were analyzed using commercially available kits and lactate levels were determined using lactate analyzers.

Statistical Analysis. In each of the studies ANOVA was used to determine pre versus post exercise differences in lactate, GH and IGF-I levels. Statistical significance was set at $p < .05$.

Results

The effect of the different typical training sessions on GH, IGF-I and lactate levels is summarized in Table 1 and Figures 1, 2, and 3. Since the different training sessions were performed on different occasions, and hormones were analyzed in different laboratories, the results are presented as percent change from baseline. However, for convenience of the readers, we also present the changes in absolute values.

Table 1 Changes in GH, IGF-I, and Lactate Levels Following Different Types of Typical (Real Life) Individual and Team Sports Practices

	GH (ng/ml)		IGF-1 (ng/ml)		Lactate (mmol/L)	
	Pre	Post	Pre	Post	Pre	Post
Cross-country female	11.1 ± 1.8	28.2 ± 4.3*	478 ± 27	476 ± 30	1.4 ± 0.2	5.6 ± 0.7*
Wrestling male	3.8 ± 1.6	5.6 ± 1.6	480 ± 36	474 ± 40	1.5 ± 0.1	9.0 ± 1.3*
Volleyball male	0.2 ± 0.2	2.7 ± 2.4*	507 ± 126	522 ± 97	3.1 ± 0.2	5.7 ± 0.5*
Volleyball female	1.8 ± 1.7	6.4 ± 3.4*	520 ± 89	538 ± 64	3.0 ± 0.2	5.1 ± 0.3*
Water polo female	3.1 ± 0.4	3.1 ± 0.8	522 ± 24	510 ± 27	0.9 ± 0.1	4.6 ± 0.7*

*Significant change from baseline, $p < .05$

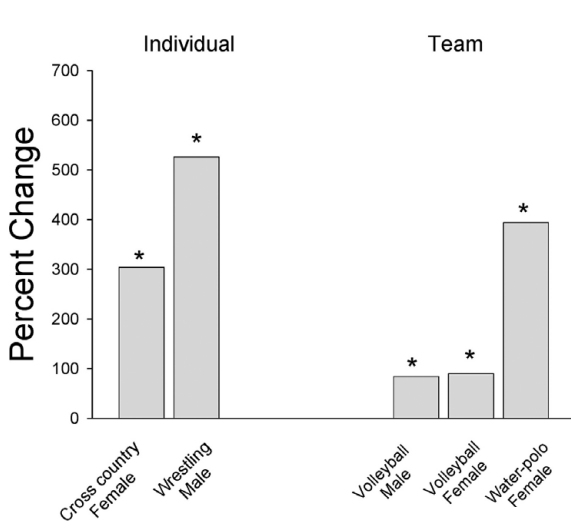


Figure 1 — Percent changes in Lactate levels following different types of typical (real life) individual and team sports practices.

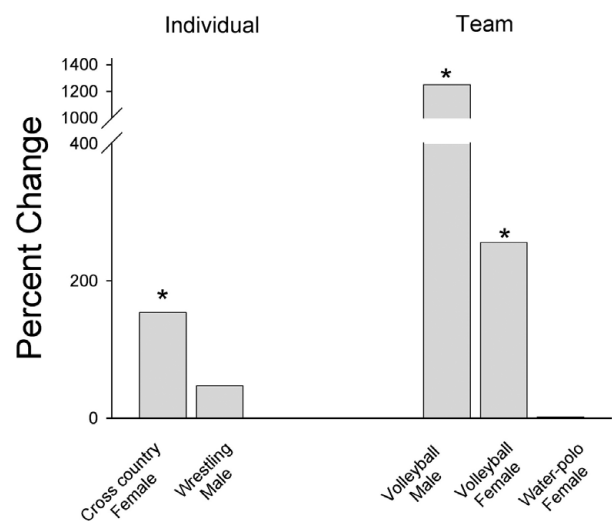


Figure 2 — Percent changes in GH levels following different types of typical (real life) individual and team sports practices.

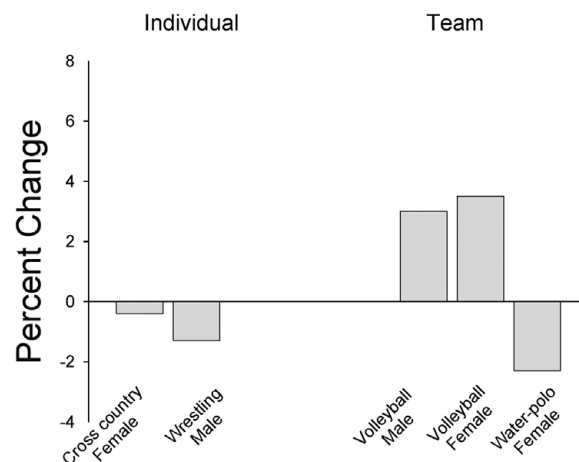


Figure 3 — Percent changes in IGF-1 levels following different types of typical (real life) individual and team sports practices.

All training sessions were associated with a significant increase in lactate levels (Figure 1). Circulating GH levels were significantly increased following the female cross-country and following the volleyball practice in both males and females, but not following the male wrestling practice and female water polo practice (Figures 2 and 3). None of the training sessions led to a significant increase in IGF-I levels.

Discussion

The aim of the current study was to compare the effect of a typical field individual and team sports training on GH and IGF levels in male and female late pubertal athletes. Since we were interested in the effect of “real-life” typical field training sessions, we were unable to control for the fitness level of the participants or for the intensity of each practice. To achieve some standardization, participants did not train during the day before the study, the duration of each practice was 60–90 min, and the practice was performed during the initial phases of the training season when athletes are in relatively lower fitness level. All practice sessions were performed in the morning hours, and each typical practice included warm-up, main part and cool-down. Blood samples were collected immediately before and at the end of practice, and the effect of the typical practice on hormonal levels was calculated as the percent change. We selected a contact and noncontact sports in the individual sport practices, and land and water sports in the team sport practices. Training sessions were performed in different occasions and hormonal levels were analyzed by different laboratories using standardized kits. Despite these limitations, several important observations and conclusions can be drawn from this unique comparison.

GH was significantly increased following the cross-country running practice and following the volleyball practice in both males and females, but not following the wrestling and water polo practice. Previous studies demonstrated that the endurance exercise-induced GH peak occurs 25–30 min after the start of aerobic exercise, irrespective of the exercise duration (5). Since GH levels were determined only before and at the end of each 1 hour practice, it is possible that an earlier, within practice, measurement could reveal a higher GH peak.

Very few studies examined the effect of gender on the GH-IGF-I response to exercise. At rest, women demonstrate an approximately twofold higher GH amplitude and GH burst secretion, with a comparable pulse frequency and GH half-life (20). Gender-related differences in the GH response were examined mainly following aerobic exercise. It was shown that both genders have a similar pattern of exercise-related GH response (17,25), but females reach peak GH concentrations sooner (26). During constant exercise duration, GH secretion is related to exercise intensity in a linear dose-dependent fashion. However, at any given exercise intensity (eg, below and above the lactic anaerobic threshold-LAT), females had higher GH concentrations (17). Interestingly, these

gender differences disappeared when endurance exercise was performed intermittently (23), and were diminished with age (22). In contrast, when exercise intensity remains constant, exercise duration significantly increases integrated GH concentration in male more than females (24). Only a single study examined the effect of 3 30-s sprints with 20-min rest between the sprints on GH secretion in active men and women. While serum GH increased similarly in both women and men, peak GH level occurred earlier in women (10). In our sample, the only practice that was studied in both male and females was the volleyball practice. We found that the percent change in GH levels was influenced mainly from the baseline GH levels. Since, as reported previously, baseline GH levels were higher among females (20), the practice-related percent change in GH levels was markedly higher the late pubertal male volleyball players (Figure 2).

The present study included both individual and team sports typical practice sessions. It is often believed that individual sports’ training is more demanding than the characteristically intermittent-type activity in team sports training. However, our results did not show differences in percent GH change following the different typical individual and team sports practice sessions. This suggests that the GH response predominantly depends on the specific exercise task.

Previous studies that examined the effects of endurance-type exercise on the GH→IGF-I axis suggested that to stimulate GH secretion, the exercise input should be sufficient (above the lactic anaerobic threshold-LAT) to cause a sizeable metabolic effect. Similarly, an increase of other hormones, that may mediate the GH response, like catecholamines, cortisol and inflammatory cytokines, also occurs only or mainly during exercise above the LAT (12). More recently it was shown that increases in exercise intensity (25%, 75%, 100%, 125%, and 175% of LAT) during constant exercise resulted in increased GH secretion in a linear dose-dependent manner (17). Consistent with that, percent changes in GH secretion were not related to changes in lactate levels following the different typical field practice sessions in the current study. Despite mild changes in lactate in the volleyball practices in both males and females, there was a marked GH percent change. In contrast, despite the greatest increases in lactate concentrations following the wrestling practice, increases in GH were not significant and there was no change in GH levels following the water polo practice.

Interestingly, GH levels were unchanged following the water polo practice suggesting a possible effect of water or water temperature on the GH response. To the best of our knowledge, our previous report is the only study that determined the GH response to water polo practice (16). Consistent with this hypothesis, previous animal studies demonstrated an inhibitory effect of chronic swimming stress on basal and post swimming GH levels in rats (2). Moreover, Vigas et al (21) showed that the GH response to swimming was higher when the temperature of the water was 36 °C compared with 29 °C in nontrained

subjects. In contrast, other investigators found no difference between the GH response to bicycling, swimming, and sauna bathing (4). Bonifazi and colleagues found an increase of GH levels following swimming practice, and that this increase is greater in later phases of the training season suggesting an anabolic adaptation to training (3). Further studies are needed to clarify the effect of different types of water sports and training on the GH response, and the significance of the finding of water-attenuated GH response to the overall training process.

Finally, none of the typical field practice sessions was associated with a significant increase in IGF-I levels. IGF-I plays a central role in the exercise-induced muscle adaptation (1). Previous laboratory-setting exercise reports suggested that very short supra-maximal exercise efforts (eg, 3 consecutive Wingate anaerobic tests—90sec; 19) and intense aerobic exercise (eg, 10 min of cycle ergometry above the LAT; 18) lead to increases in IGF-I levels. It is possible, therefore, that the present “real-life” typical field individual and team sports practices were not intense enough to increase IGF-I levels.

In summary, we compared our reports on the effect of real-life typical field individual (ie, cross-country and wrestling) and team (ie, volleyball and water polo) sports training on GH and IGF, the main growth factors of the GH/IGF axis, in male and female late pubertal athletes. Cross-country running practice and volleyball practice in both males and females were associated with significant increases of GH, while none of the practices led to a significant increase in IGF-I levels. The magnitude (percent change) of the GH response to the different practices was determined mainly by preexercise GH levels. There was no difference in the GH response between individual and team sports practices. The GH response to the typical practices was not influenced by the practice-associated lactate change. Further studies are needed to better understand the effect of real-life typical training in adolescent athletes and their role in exercise adaptations.

Reference

- Adams GR. Autocrine/paracrine IGF-I and skeletal muscle adaptation. *J Appl Physiol*. 2002; 93:1159–1167. [PubMed](#)
- Armario A, Garcia-Marquez C, Jolin T. The effects of chronic intermittent stress on basal and acute stress levels of TSH and GH, and their response to hypothalamic regulatory factors in the rat. *Psychoneuroendocrinology*. 1987; 12(5):399–406. [PubMed doi:10.1016/0306-4530\(87\)90069-2](#)
- Bonifazi M, Bela E, Lupo C, Martelli G, Zhu B, Carli G. Influence of training on the response to exercise of adrenocorticotropin and growth hormone plasma concentrations in human swimmers. *Eur J Appl Physiol Occup Physiol*. 1998; 78(5):394–397. [PubMed doi:10.1007/s004210050436](#)
- Doré S, Brisson GR, Fournier A, Montpetit R, Perrault H, Boisvert D. Contribution of hGH20K variant to blood hGH response in sauna and exercise. *Eur J Appl Physiol Occup Physiol*. 1991; 62(2):130–134. [PubMed doi:10.1007/BF00626768](#)
- Eliakim A, Nemet D. Exercise provocation test for growth hormone secretion. *Pediatr Exerc Sci*. 2008; 20:370–378. [PubMed](#)
- Eliakim A, Nemet D. Exercise training, physical fitness and the growth hormone-insulin-like growth factor-1 axis and cytokine balance. *Med Sport Sci*. 2010; 55:128–140. [PubMed doi:10.1159/000321977](#)
- Eliakim A, Nemet D. The endocrine response to exercise and training in young athletes. *Pediatr Exerc Sci*. 2013; 25:605–615. [PubMed](#)
- Eliakim A, Nemet D, Cooper DM. Exercise, training and the GH→IGF-I axis. In: Kraemer WJ, Rogol A.D, editors. *The endocrine system in sports and exercise*. Oxford, UK: Wiley-Blackwell, 2005: 165–179.
- Eliakim A, Portal S, Zadik Z, et al The effect of volleyball training on anabolic hormones and inflammatory markers in elite male and female adolescent players. *J Strength Cond Res*. 2009; 23:1553–1559. [PubMed doi:10.1519/JSC.0b013e3181aa1bcb](#)
- Esbjörnsson M, Norman B, Suchdev S, Viru M, Lindhgren A, Jansson E. Greater growth hormone and insulin response in women than in men during repeated bouts of sprint exercise. *Acta Physiol (Oxf)*. 2009; 197(2):107–115. [PubMed doi:10.1111/j.1748-1716.2009.01994.x](#)
- Meckel Y, Eliakim A, Seraev M, et al The effect of a brief sprint interval exercise on growth factors and inflammatory mediators. *J Strength Cond Res*. 2009; 23(1):225–230. [PubMed doi:10.1519/JSC.0b013e3181876a9a](#)
- Nemet D, Eliakim A. Growth hormone-insulin-like growth factor-1 and inflammatory response to a single exercise bout in children and adolescents. *Med Sport Sci*. 2010; 55:141–155. [PubMed doi:10.1159/000321978](#)
- Nemet D, Eliakim A, Mills PJ, Meckel Y, Cooper DM. Immunological and growth factor response to cross-country training in adolescent females. *J Pediatr Endocrinol Metab*. 2009; 22:995–1007. [PubMed](#)
- Nemet D, Mills PJ, Cooper DM. Effect of intense wrestling exercise on leucocytes and adhesion molecules in adolescent boys. *Br J Sports Med*. 2004; 38(2):154–158. [PubMed doi:10.1136/bjism.2002.002576](#)
- Nemet D, Oh Y, Kim HS, Hill M, Cooper DM. Effect of intense exercise on inflammatory cytokines and growth mediators in adolescent boys. *Pediatrics*. 2002; 110(4):681–689. [PubMed doi:10.1542/peds.110.4.681](#)
- Nemet D, Rose-Gottron CM, Mills PJ, Cooper DM. Effect of water polo practice on cytokines, growth mediators, and leukocytes in girls. *Med Sci Sports Exerc*. 2003; 35(2):356–363. [PubMed doi:10.1249/01.MSS.0000048722.84182.E3](#)
- Pritzlaff-Roy CJ, Wideman L, Weltman JY, et al Gender governs the relationship between exercise intensity and growth hormone release. *J Appl Physiol*. 2002; 92:2053–2060. [PubMed](#)
- Schwarz AJ, Brasel JA, Hintz RL, Mohan S, Cooper DM. Acute effect of brief low- and high-intensity exercise on circulating IGF-I, II, and IGF binding protein-3 and

- its proteolysis in young healthy men. *J Clin Endocrinol Metab.* 1996; 81:3492–3497. [PubMed](#)
19. Stokes K, Nevill M, Frystyk J, Lakomy H, Hall G. Human growth hormone response to repeated bouts of sprint exercise with different recovery periods between bouts. *J Appl Physiol.* 2005; 99:1254–1261. [PubMed doi:10.1152/jappphysiol.00839.2004](#)
 20. Veldhuis JD, Bowers CY. Human GH pulsatility: an ensemble property regulated by age and gender. *J Endocrinol Invest.* 2003; 26:799–813. [PubMed](#)
 21. Vigas M, Celko J, Koska J. Role of body temperature in exercise-induced growth hormone and prolactin release in non-trained and physically fit subjects. *Endocr Regul.* 2000; 34(4):175–180. [PubMed](#)
 22. Weltman A, Weltman JY, Roy CP, et al Growth hormone response to graded exercise intensities is attenuated and the gender difference abolished in older adults. *J Appl Physiol.* 2006; 100:1623–1629. [PubMed doi:10.1152/jappphysiol.01312.2005](#)
 23. Weltman A, Weltman JY, Watson Winfield DD, et al Effects of continuous versus intermittent exercise, obesity, and gender on growth hormone secretion. *J Clin Endocrinol Metab.* 2008; 93(12):4711–4720. [PubMed doi:10.1210/jc.2008-0998](#)
 24. Wideman L, Consitt L, Patrie J, et al The impact of sex and exercise duration on growth hormone secretion. *J Appl Physiol.* 2006; 101:1641–1647. [PubMed](#)
 25. Wideman L, Weltman JY, Patrie JT, et al Synergy of L-arginine and GHRP-2 stimulation of GH in men and women: modulation by exercise. *Am J Physiol Regul Integr Comp Physiol.* 2000; 279:R1467–R1477. [PubMed](#)
 26. Wideman L, Weltman JY, Shah N, Story S, Veldhuis JD, Weltman A. Effects of gender on exercise-induced growth hormone release. *J Appl Physiol.* 1999; 87:1154–1162. [PubMed](#)

Copyright of Pediatric Exercise Science is the property of Human Kinetics Publishers, Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.