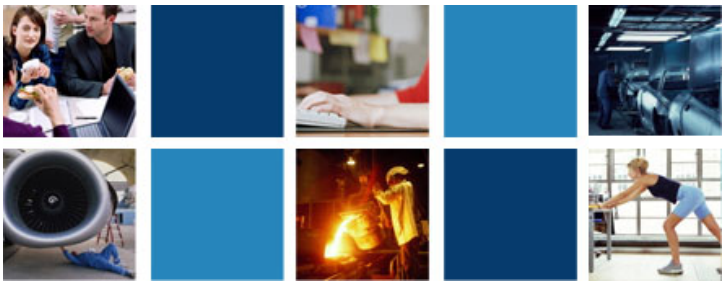
UNITED STATES ERGONOMICS



Ergonomics Analyses of Crocs Footwear

March 7, 2005

Prepared for:

Crocs Footwear

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The Evolution of Ergonomics

Executive Summary

Ergonomics testing was completed on Crocs footwear products by Certified Professional Ergonomists to assess product performance with regard to key ergonomics criteria for comfort and performance. Measurements included pressure mapping of the foot, muscle effort testing of the lower leg, and subjective survey by test subjects. In addition, a review of the footwear design elements was conducted.

A total of five subjects tested the Crocs in standing and walking conditions on a concrete flooring surface during which pressure mapping and muscle activity data were collected. The pressure data were compared to similar measurements from each test subject's "most physically comfortable" personal footwear. Muscle effort data compared standing and walking in the Crocs to a baseline of barefoot standing and walking. In addition, an extended period of standing was tested to assess fatigue potential.

The results indicate statistically significant ergonomics advantages for the Crocs footwear among the key variables affecting user comfort, effort and fatigue potential. Several of the key findings are as follows:

- The Crocs performed as good or better than the test subjects' most physically comfortable footwear.
- The Crocs provide meaningful functional support to the user as evidenced by reduced muscle activity levels during use.
- Low levels of muscle activity over prolonged periods of standing indicate that the Crocs can reduce fatigue potential.
- The test subjects rated the Crocs very highly, placing them in the "Good" to "Excellent" category for overall comfort and performance.
- The lightweight design, ease of getting on and off, potential for orthotics, and sizing & support provided by the heel strap provide the flexibility for the Crocs to accommodate a large percentage of the population.
- The ease of cleaning the shoes make them very desirable for applications where cleanliness is important (e.g., hospitals, food preparation, clean rooms)

It is recommended that the Crocs footwear be considered for use in a variety of applications where prolonged standing or walking may tend to induce foot discomfort or lower body fatigue.

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1.0 Introduction

Ergonomics testing was completed on Crocs footwear products by Certified Professional Ergonomists. The purpose was to determine if the shoes meet desirable ergonomics criteria for comfort and performance. The testing involved, pressure mapping of the plantar (bottom) surface of the foot in the shoes, muscle effort testing of the lower legs, and subjective comfort surveys from individuals. A description of the test methods, results and conclusions are presented in the following sections.

2.0 Ergonomics Testing Methods & Results

Ergonomics measurements techniques were applied to objectively compare the performance of individuals using the product. Through these techniques it was possible to assess the overall physical requirements of the products use, thereby determining pressure/fit advantages, leg muscle effort requirements and perceived levels of comfort.

The Crocs shoes in the Metro and the Cayman styles were included in the testing. Testing was conducted on a total of Five (5) individuals selected to represent an anthropometric range of the anticipated user population (5th percentile female to 95th percentile male). Users were monitored during a series of walking and standing tests performed on concrete flooring. Subjects were asked to walk at a self-selected normal speed (A.J. Taylor, et. al., 2004).

The results of the objective testing were statistically analyzed using t-Tests to assess significant differences among key variable. Confidence intervals were established at the 95^{th} percentile ($p<0.05$).

Further test descriptions are presented in the following sections:

2.1Subject Population

A total of five healthy subjects (3 females, 2 males) participated in the testing. Each subject had been given a pair of the Crocs to wear prior to the testing. Subjects estimated the time they had worn the Crocs to be between 0.5 hrs and 20 hrs with an average of 8.3 hours of wear prior to testing. The ages of the subjects ranged from 37 to 45 years with an average age of 39.5. The reported shoe sizes tested include women's sizes 5, 7 and 9 and men's sizes 9 and 12. The subject weights varied between 105 lbs to 213 lbs with an average weight of 149 lbs. One subject indicated a preference for the use of inserts for arch support, this subject tested the Crocs with and without the arch supports.

2.2 Contact Pressure

2.2.1 Test Methods

Contact force and pressure were measured on the plantar surface of the shoe using flexible force sensors. A Tekscan F-Scan system was utilized for the testing. The pressure distribution of the Crocs shoes were compared to each subjects' "most physically comfortable" footwear. These included sneakers (Nike, New Balance), soft soled pull on shoes (e.g., Merrils & Timberlands) and sandals.

Prior research has correlated increased user comfort with decreased pressure and forces on the foot (C Jordan and R Bartlett 1995, H. Che, B. M. Nigg, et. al. 1994). These criteria include a reduction in the total force on the plantar surface of the foot, the characteristics of the migration of the center of force during walking, and the pressure across the midfoot area during walking. Several of these and other variables were obtained from the testing.

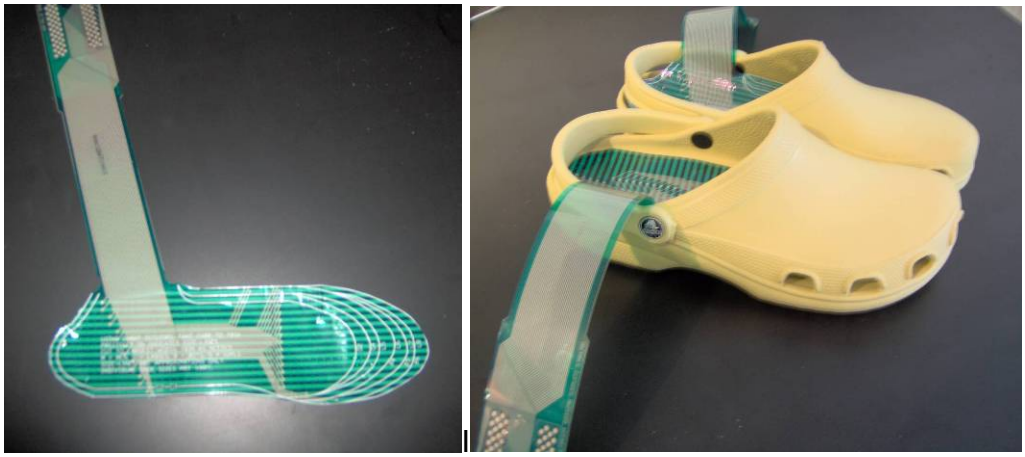
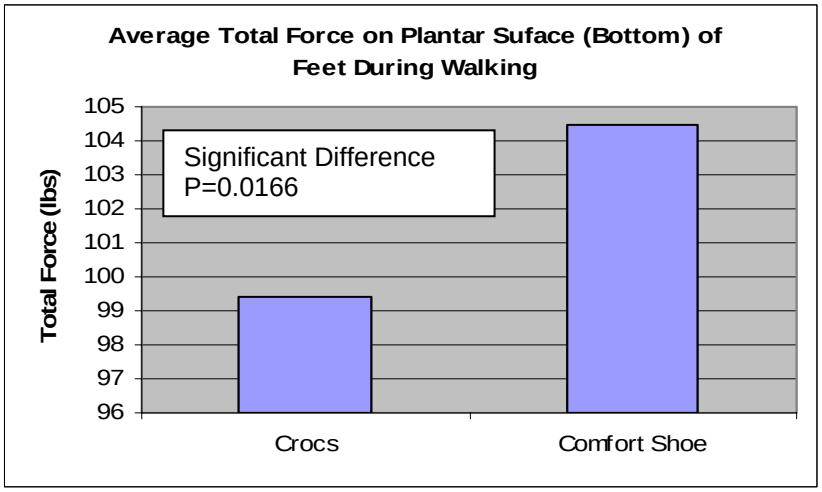


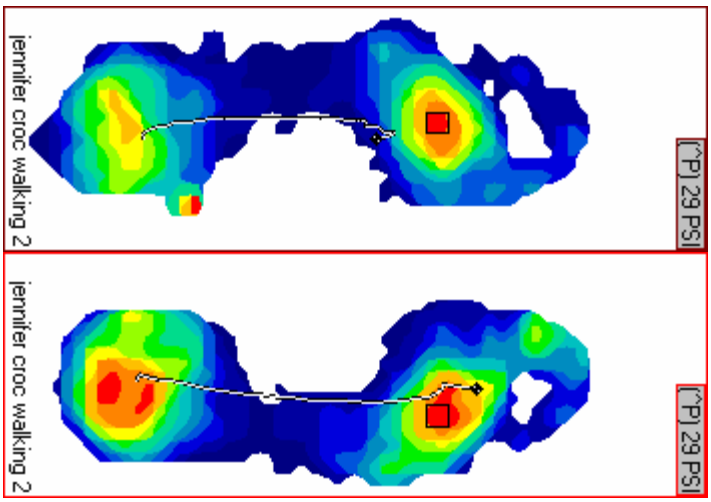
Illustration of pressure mapping sensors in Crocs

Subjects prepared for testing in Crocs verses "Most physically comfortable" personal footwear

2.2.2 Test Results

The results indicate that the Crocs shoes resulted in significantly lower total mean forces across the plantar surface of the foot during walking when compared to the users personal “most physically comfortable” footwear. On average a reduction of approximately 5% was recorded with the Crocs footwear. This indicates that the Crocs shoes provide potentially higher comfort than each individuals most comfortable shoes.

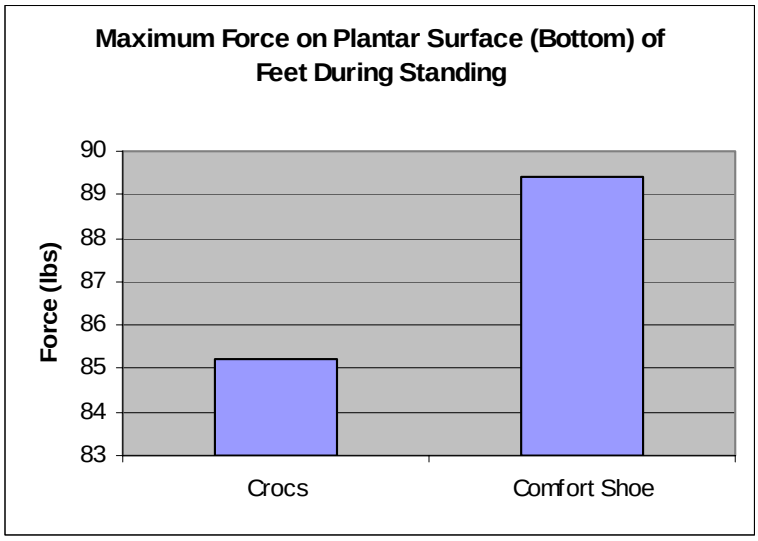




Sample pressure mapping results

Reports from Crocs design and development experts indicate that the Crocs material will conform slightly over time (estimated at 10%-20%), making them even more effective at reducing plantar surface forces, a main variable affecting comfort.

In addition, maximum forces were also lower with the Crocs footwear during standing. While showing a positive trend, the difference was not statistically significant (P=0.12) at the 95th percentile confidence level.



Visual plots illustrating the migration of the center of pressure indicated no apparent differences between the Crocs and the users most comfortable footwear. Plots of the summarized pressure data are presented in App. A.

2.3 Muscle Effort Levels

2.3.1 Test Methods

Muscle activity levels were monitored among four key muscle groups of the dominant leg using electromyography (EMG). Subjects were measured during standing and walking activities. The muscle groups monitored included the lateral and medial Gastrocnemius muscles, the Tibialis anterior, and the Peroneus muscles. These muscle are the superficial muscles of the lower leg primarily involved in flexing and extending the foot during walking activities.

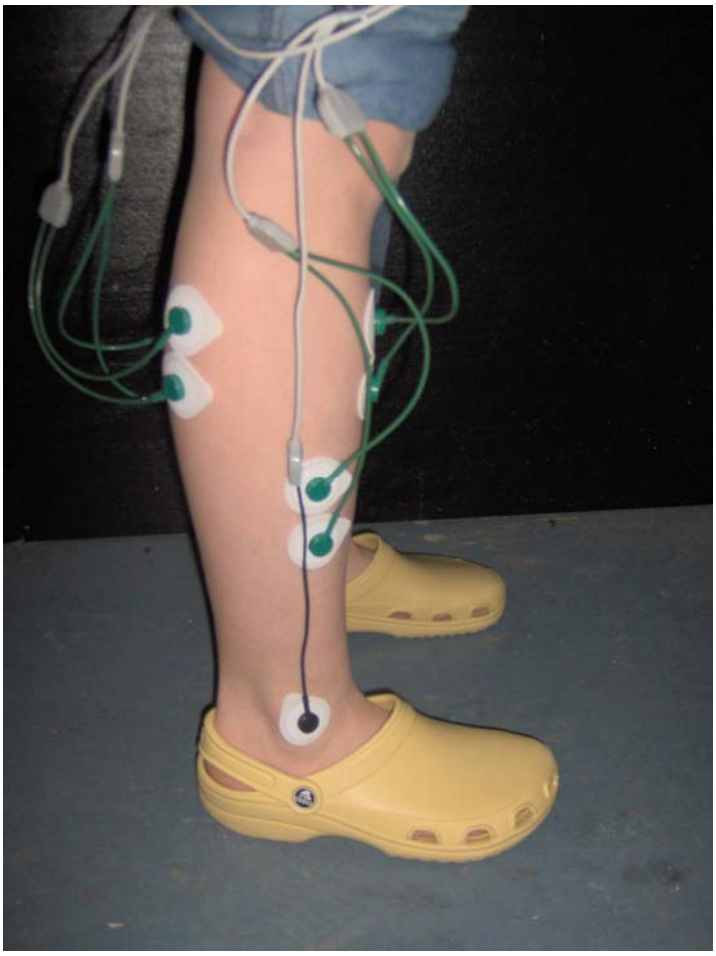
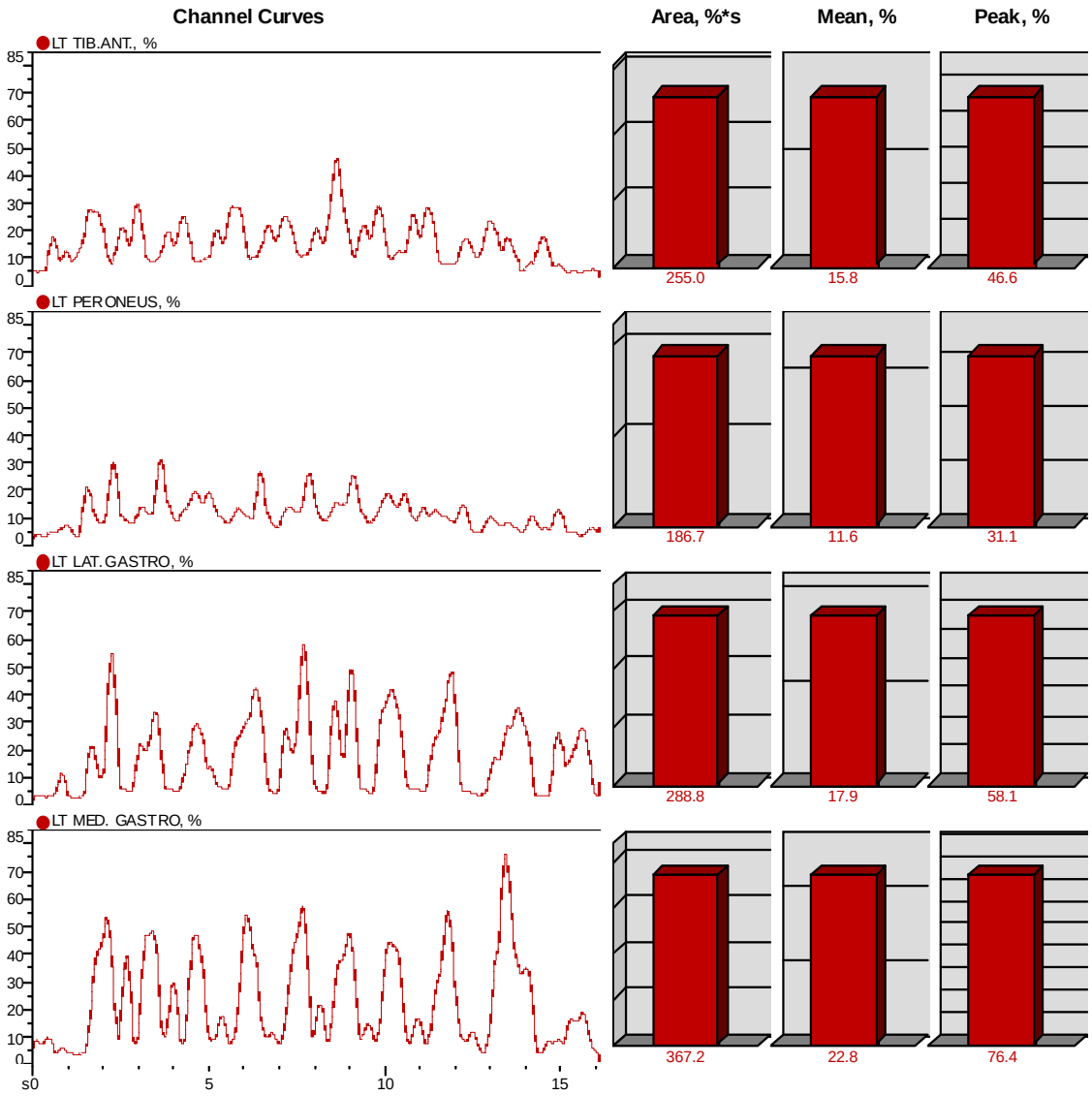


Illustration of test subject wired for muscle effort monitoring

Effort levels were calibrated to a maximum voluntary contraction (%MVC) of the muscles for each individual subject. Activity levels were recorded during standing and walking activities(see Graph next page). To establish a point of reference the effort associated while wearing the Crocs was compared to the effort associated with similar activities performed barefoot.

In addition, the subjects were asked to stand in a fixed position for 20 minutes on a concrete surface to assess fatigue potential.

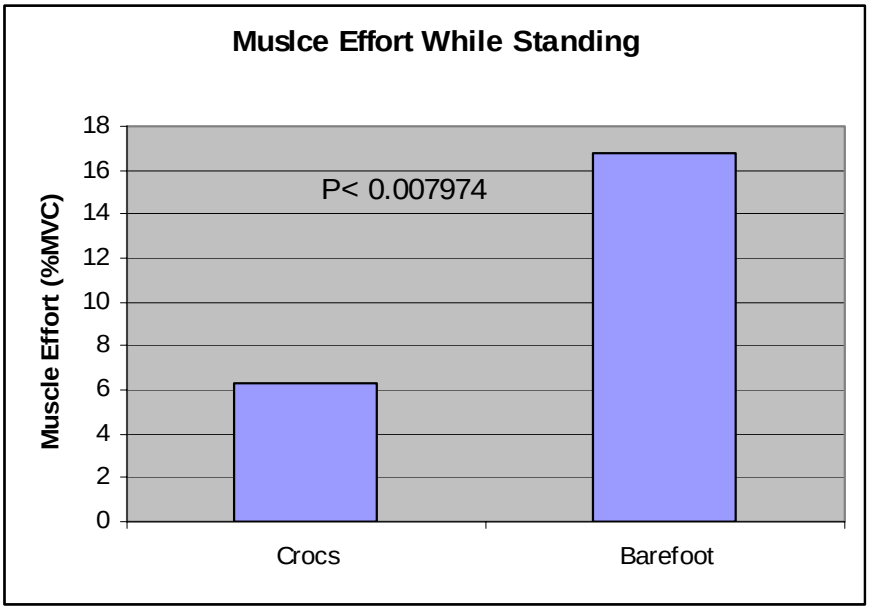


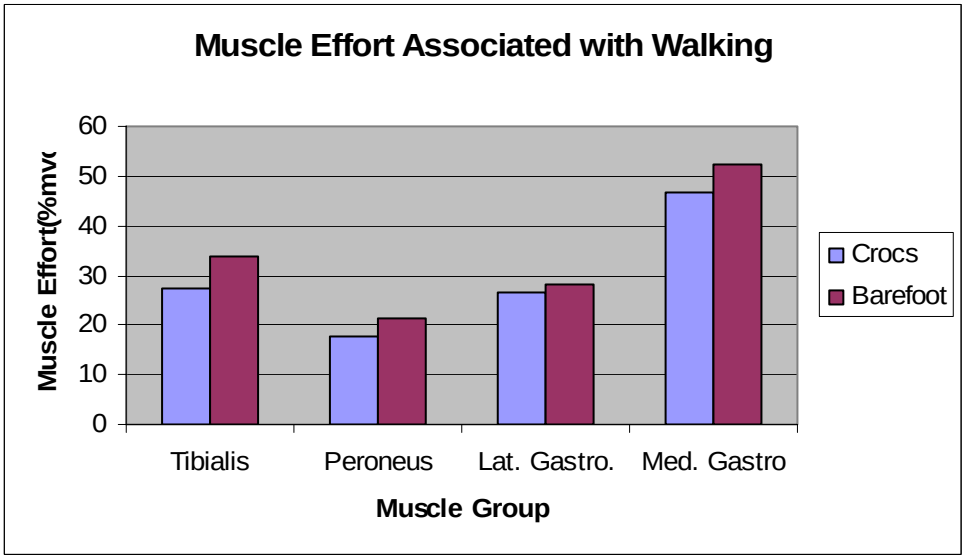
Sample muscle effort measurement recorded while walking with Crocs

2.3.2 Test Results

Overall, the Crocs required less effort during standing and walking when compared to the reference of walking barefoot (see Graphs below) indicating that the shoes provide meaningful functional support to the user. The trend was positive for each of the muscle groups monitored and the results were statistically significant (P=0.007974) for the standing task which showed a 62.6% reduction in effort.

In addition, an analysis of continuous standing indicated no increase in muscle activity levels after static standing on concrete flooring for 20 minutes. The average muscle effort levels were maintained below 7% maximum voluntary contraction (%mvc) indicating that lower leg fatigue is not likely to occur.

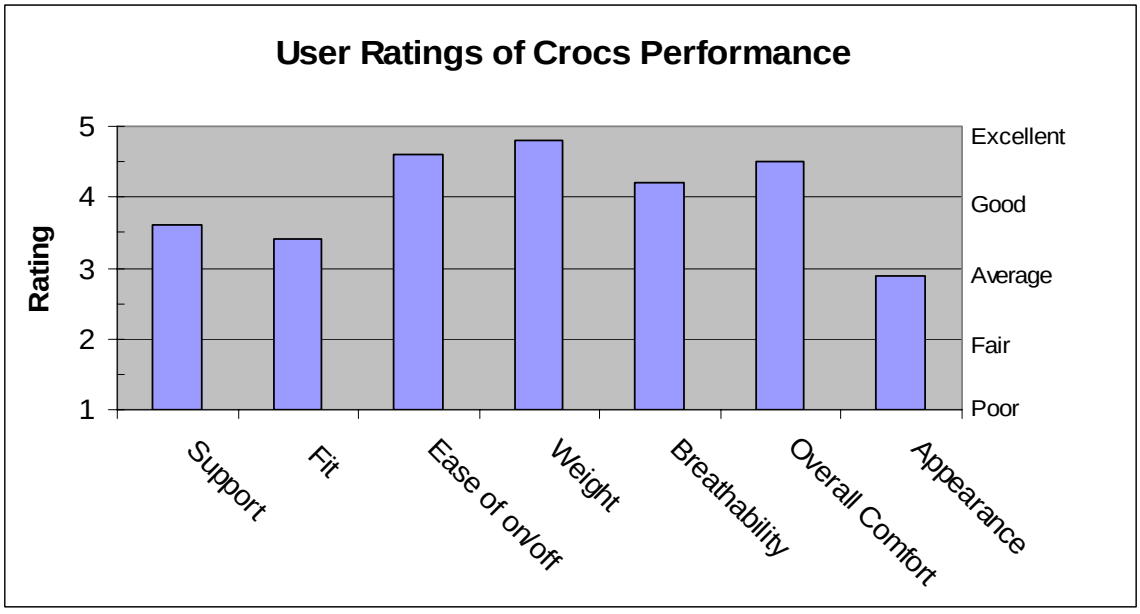




2.4 Subject Surveys

Subjects were asked to rate a variety of shoe features with regard to their perceived comfort and preference using a 5-point scale (5= “Excellent”, 1= “Poor”). Questions pertaining to shoe fit, comfort, support, breathability, etc. were recorded. In addition, a rating for appearance was recorded to gauge aesthetic perceptions influence on user ratings.

Overall the Crocs received an average 4.2 out of 5 rating by all subjects for the ergonomics criteria. This corresponds to a better than “Good” perception by the test subjects of the Crocs footwear. This average does not include the rating for appearance (as it has no bearing on the ergonomics performance) which received a rating close to “Average”.



In particular it was the light weight of the shoes, ease of getting the shoes on or off, and the overall comfort that received the highest ratings. The subject comments supported the ratings received. Several comments are as follows:

> “Comfortable & easy”
>
> “Good foot bed and side support”
>
> “Good fit and support, nice and light”
>
> “The fact that they’re so light is great. I’ve worn them all day with no problem”

2.5 Design Review

Ergonomics features of the shoes were assessed by a Certified Professional Ergonomist (CPE). A summary of the design elements of the Crocs that affect the overall ergonomics performance are provided below:

2.5.1 Shoe Fit

The Crocs are available in whole sizes only. However, the option to use or not use the rear strap provides adjustability in the fit. If the shoe is slightly small, it is recommended that the rear strap not be used. The subjects tested did not have difficulty finding a shoe the fit them well. The shoes are available in whole sizes as follows:

Caymens:	Metro
Women's sizes 3-12	Women's sizes 6-12
Men's sizes 5-13	Men's sizes 4-13

2.5.2 Shoe Weight

The shoes are extremely lightweight while providing structural support. The value of this combination was evident in the reduced muscle effort levels while wearing the shoes. On average the effort to walk in the Crocs was less than that required to walk barefoot. When standing the differences were significant ($P<.01$), resulting in a 62.6% reduction in the overall muscle effort compared to standing barefoot. The subjects rated the weight of the shoes as "Excellent" .

2.5.3 Ease of Getting On/Off

The clog style openness of the design allows for ease of getting the shoe on and off. In addition, the optional support provided by the heel strap provides the user with flexibility not found in a traditional clog.

2.5.4 Breathability

The Crocs tested possess ventilation holes along the outer edges of the forefoot as well as on top of the forefoot in the Cayman style. Our test subjects rated the breathability of the shoes as Good. It is recommended that users select models that provide the ventilation appropriate for their anticipated environmental conditions (e.g., select a Caymen style for warmer conditions). The use of peds of socks may enhance the breathability of the foot.

2.5.4 Use of Inserts & Orthotics

The insole of the Crocs provides adequate space and a depth to effectively accommodate the use of a shoe insert or orthotic. Users with prescription orthotics should have no difficulty using them in the Crocs footwear.

2.5.5 Ease of Cleaning

The shoes may be cleaned or sterilized by emersion in soapy water or bleach. This is a major benefit for industries where cleanliness is required (e.g., health care, food service, clean rooms).

3.0 Conclusions

The results of the ergonomics testing indicate that the Crocs footwear performed very well for the key variables affecting user comfort, effort and fatigue potential. Several of the key findings are as follows:

- Pressure and force mapping reveal that the Crocs performed as good or better than the test subjects' most physically comfortable footwear.
- The Crocs provide meaningful functional support to the user as evidenced by reduced muscle activity levels during use.
- Low levels of muscle activity over prolonged periods of standing indicate that the Crocs can reduce fatigue potential.
- The test subjects rated the Crocs very highly, placing them in the "Good" to "Excellent" category for overall comfort and performance.
- The lightweight design, ease of getting on and off, potential for orthotics, and sizing & support provided by the heel strap provide the flexibility for the Crocs to accommodate a large percentage of the population.
- The ease of cleaning the shoes make them very desirable for applications where cleanliness is important (e.g., hospitals, food preparation, clean rooms)

It is recommended that the Crocs footwear be considered for use in a variety of applications where prolonged standing or walking may tend to induce foot discomfort or lower body fatigue.

References

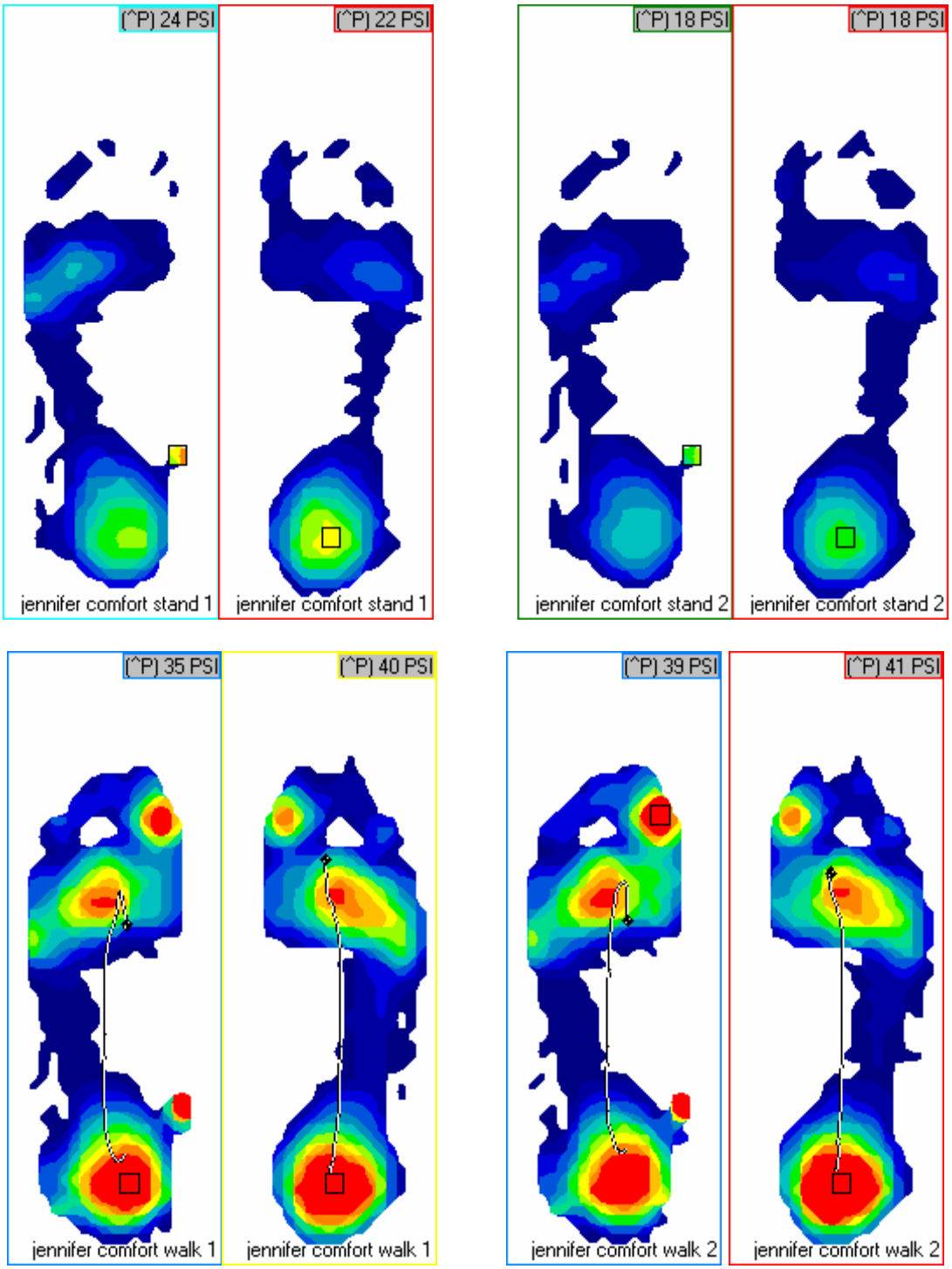
1. Pressure distribution and perceived comfort in casual footwear
C Jordan and R Bartlett
Gait & Posture, Volume 3, Issue 4, December 1995, Pages 215-220
Clinical Biomechanics, Volume 12, Issue 3, April 1997, Page S5

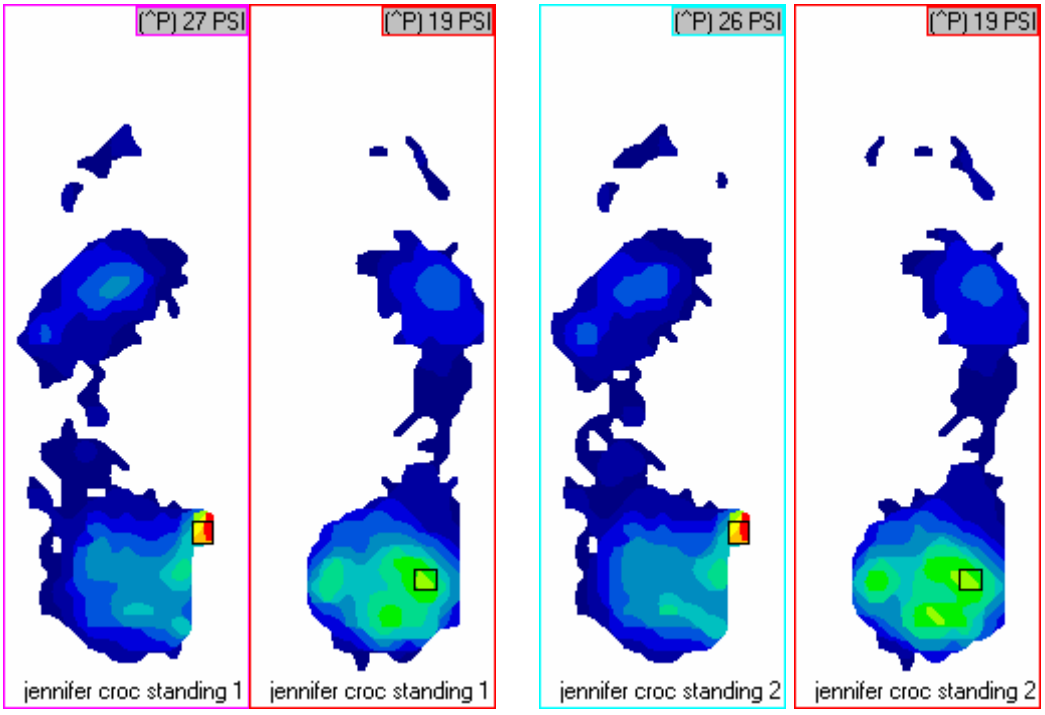
2. Relationship between plantar pressure distribution under the foot and insole comfort
H. Che, B. M. Nigg and J. de Koning
Clinical Biomechanics, Volume 9, Issue 6, November 1994, Pages 335-341

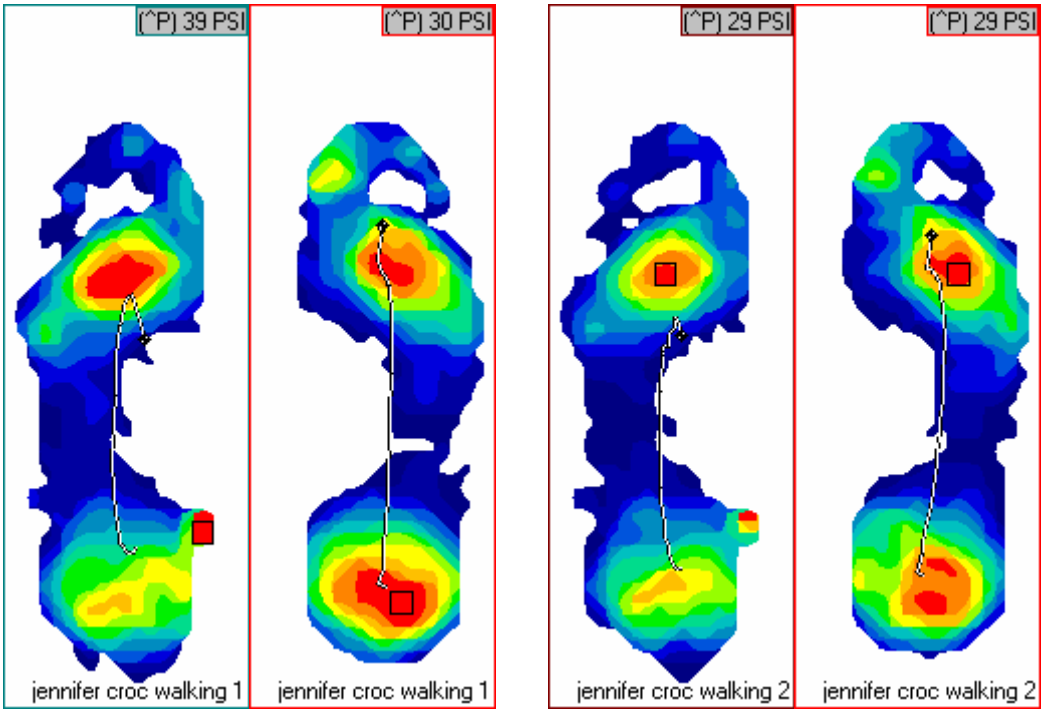
3. The influence of walking speed on plantar pressure measurements using the two-step gait initiation protocol
A.J. Taylor, H.B. Menz, A-M Keenan
The Foot, Volume 14 (2004), pages 49-55

Appendix A: Pressure Plots

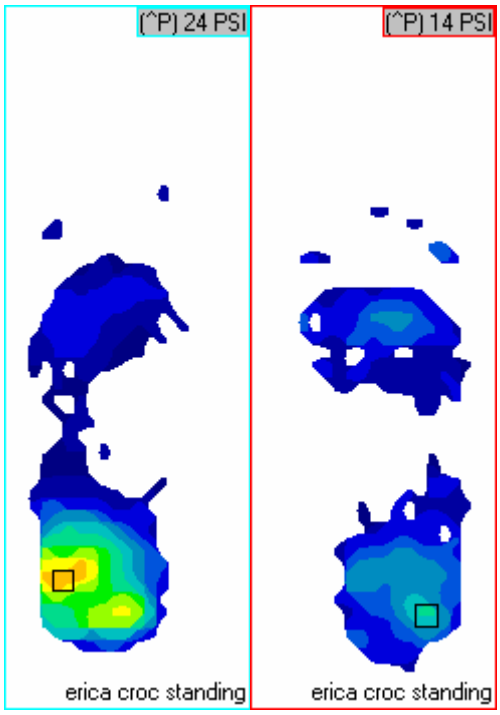
Subject 1 : Female : Size 7

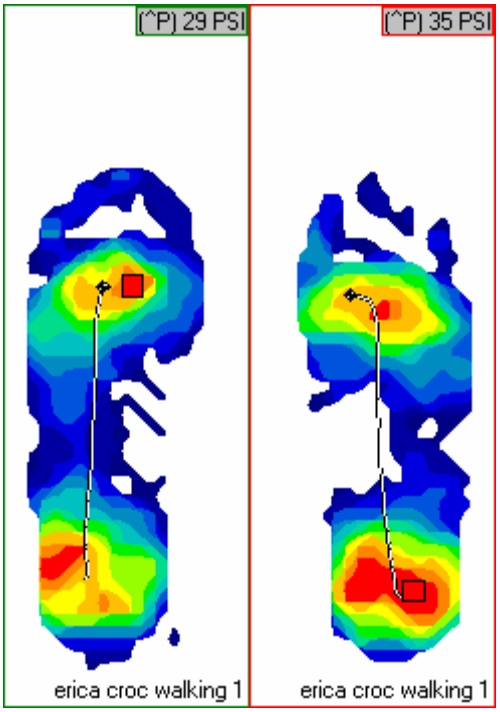


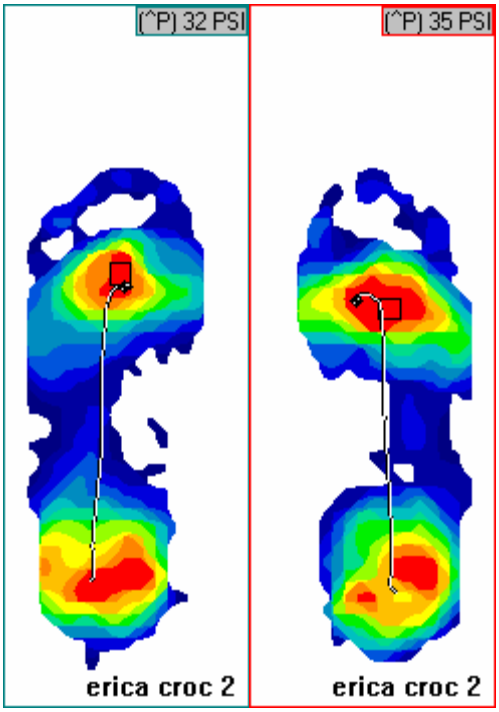

(^P) 27 PSI
(^P) 19 PSI
(^P) 26 PSI
(^P) 19 PSI
jennifer croc standing 1
jennifer croc standing 1
jennifer croc standing 2
jennifer croc standing 2

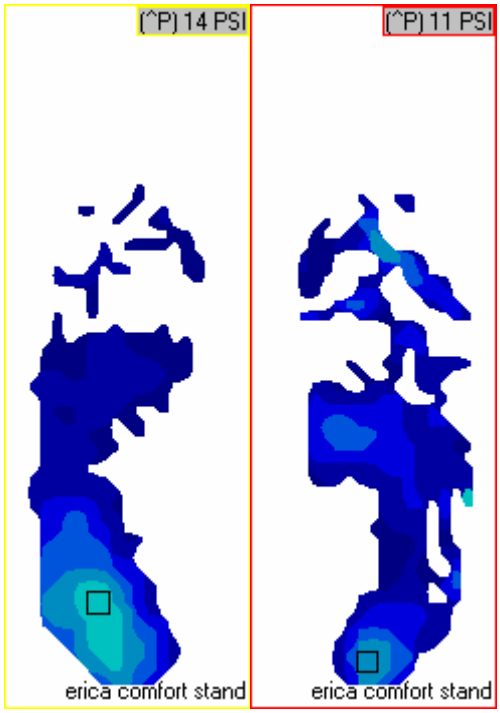

(^P) 39 PSI
(^P) 30 PSI
(^P) 29 PSI
(^P) 29 PSI
jennifer croc walking 1
jennifer croc walking 1
jennifer croc walking 2
jennifer croc walking 2

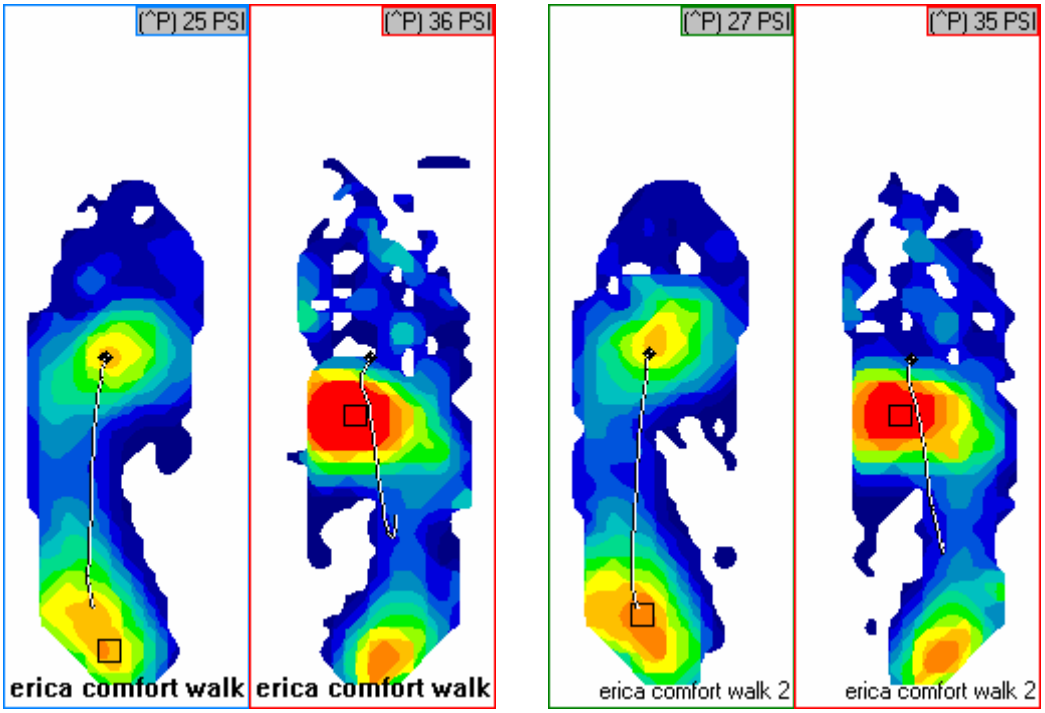
Subject 2: Female: Size 5



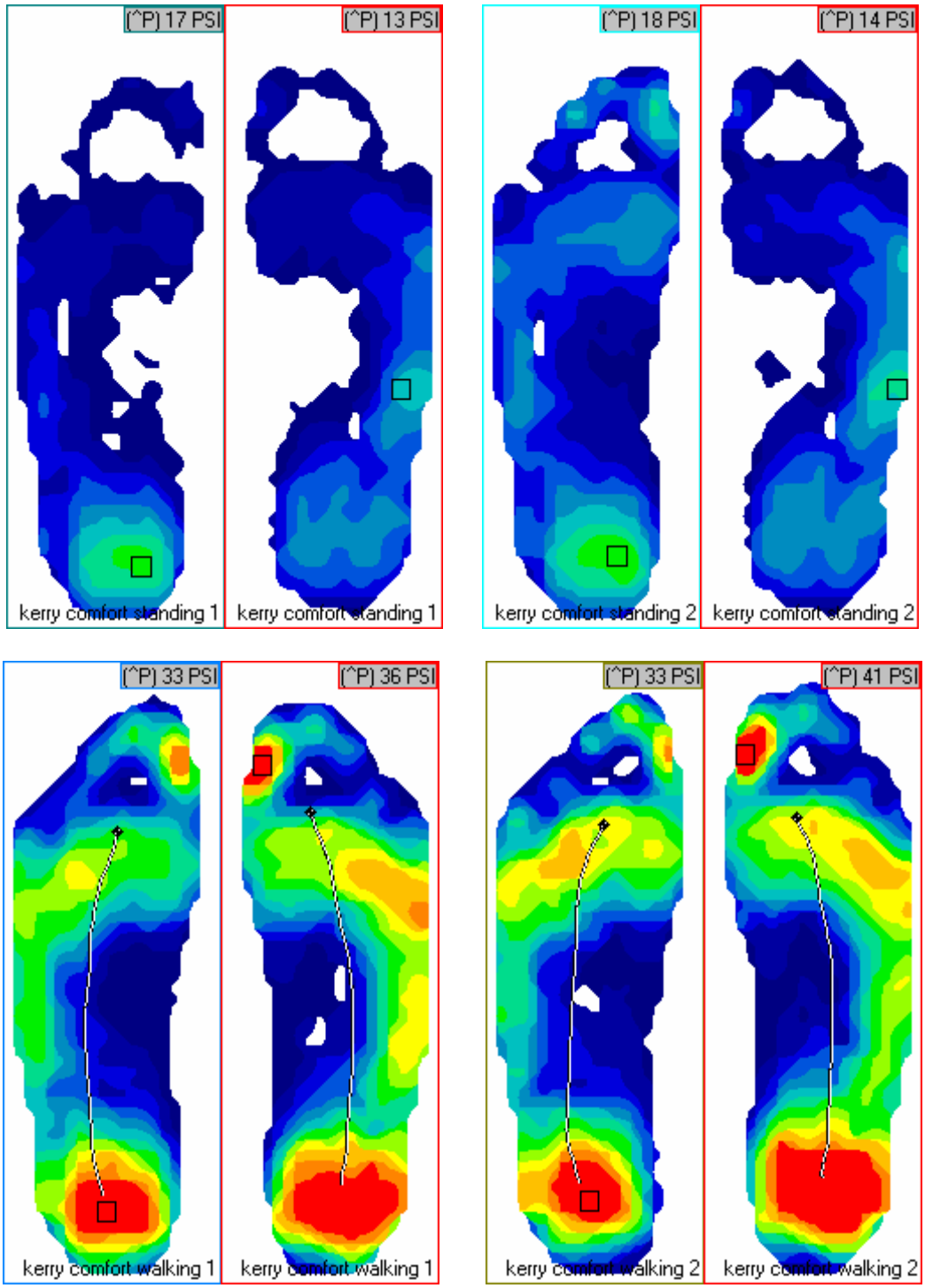


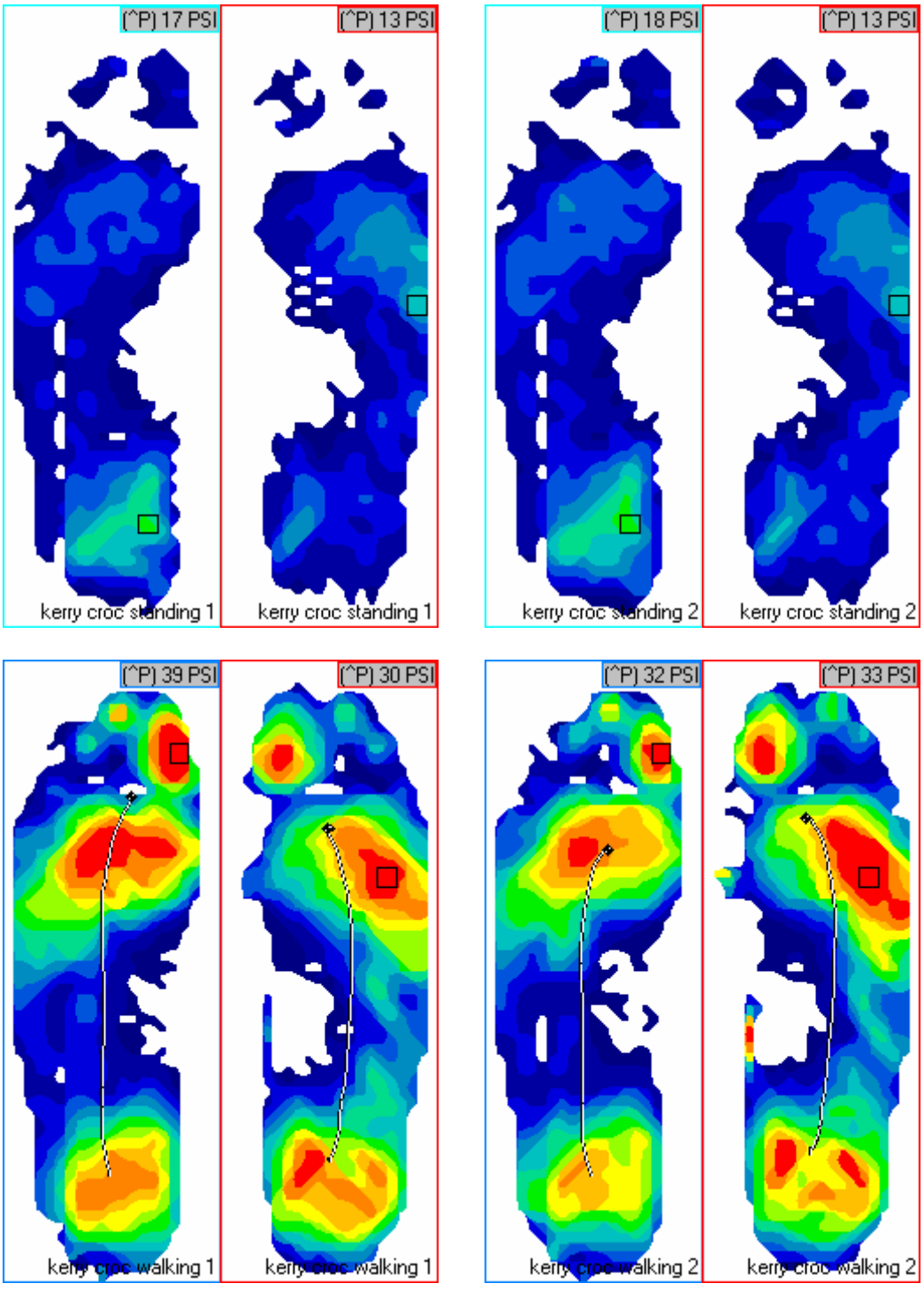



(^P) 14 PSI
(^P) 11 PSI
erica comfort stand
erica comfort stand


(^P) 25 PSI
(^P) 36 PSI
(^P) 27 PSI
(^P) 35 PSI
erica comfort walk
erica comfort walk
erica comfort walk 2
erica comfort walk 2

Subject 3 : Male : Size 12

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kerry croc standing 1
kerry croc standing 1
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kerry croc standing 2
(^P) 39 PSI
(^P) 30 PSI
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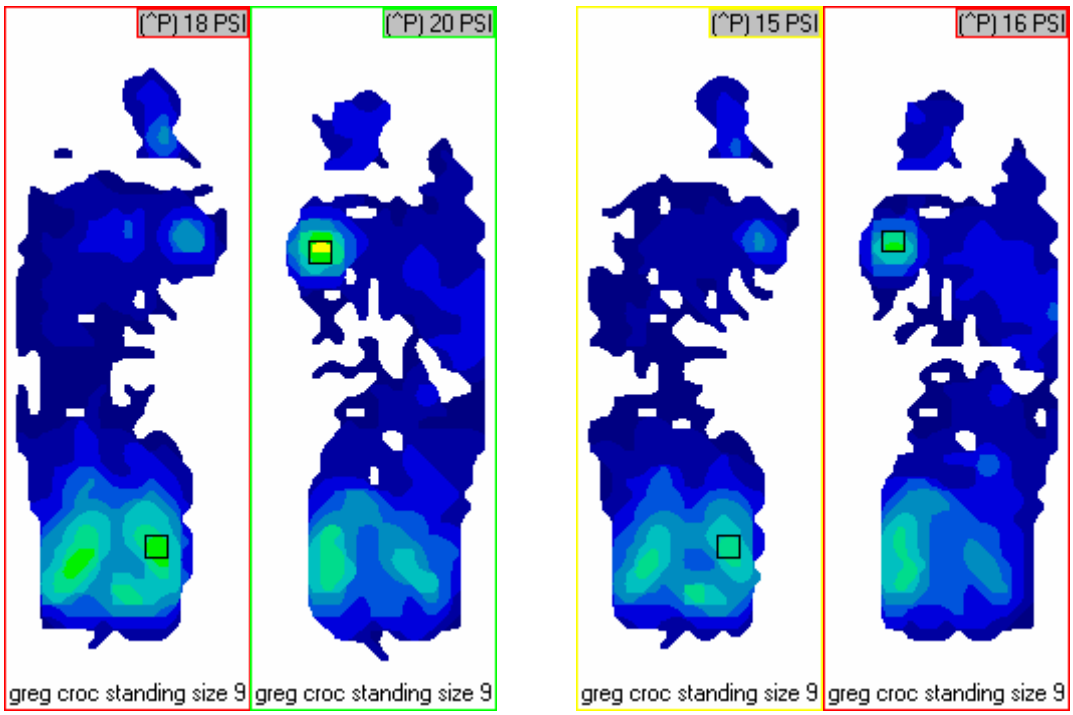
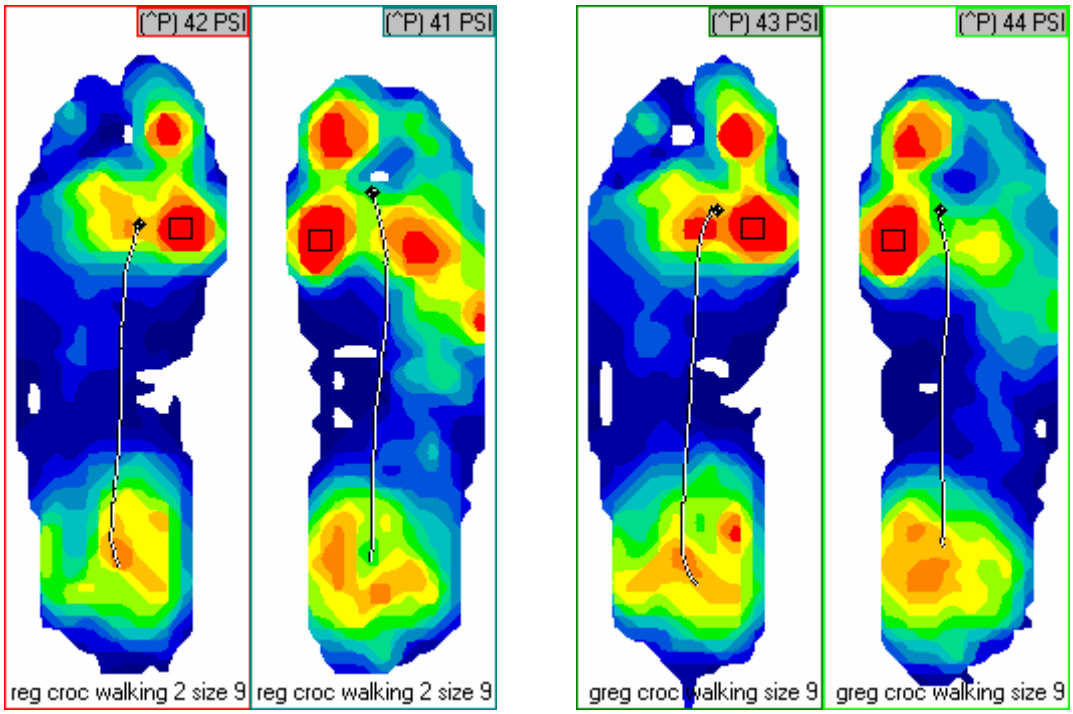
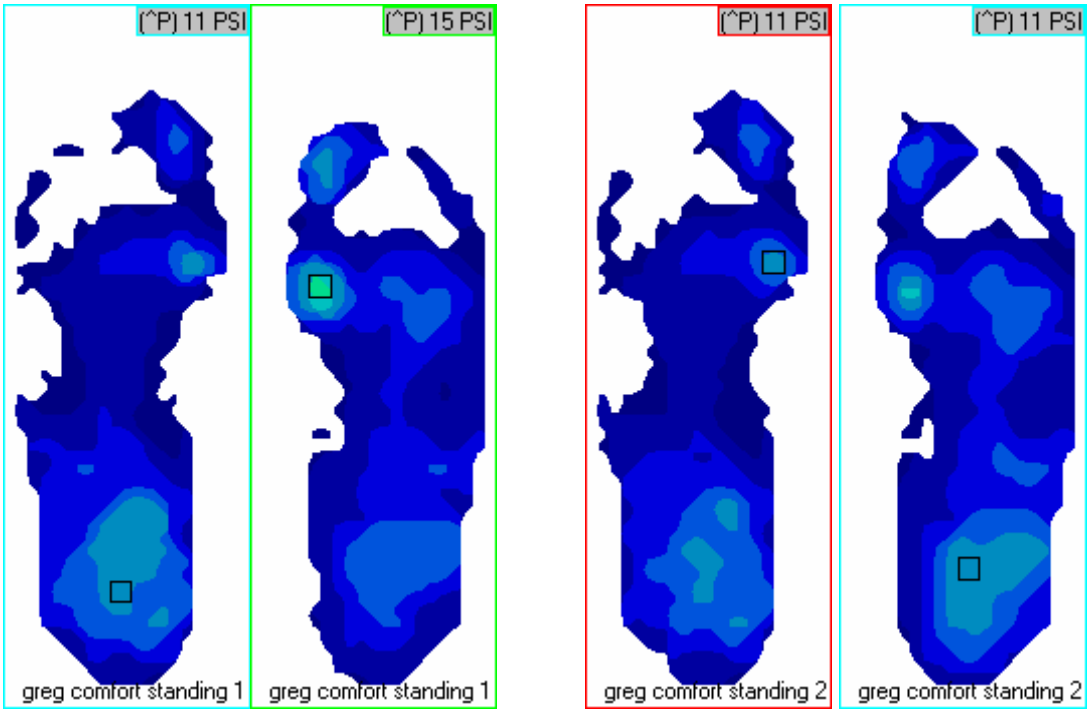
kerry croc walking 2
kerry croc walking 2

Subject 4 : Male: Size 9



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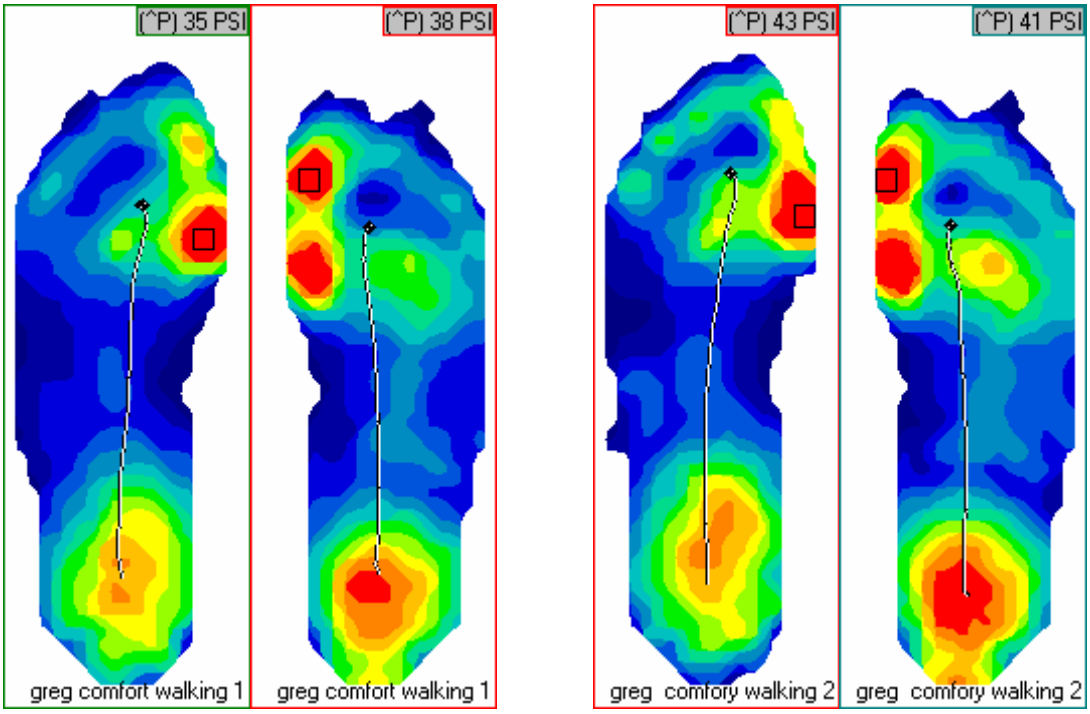
greg comfort standing 2
greg comfort standing 2


(^P) 35 PSI
(^P) 38 PSI
(^P) 43 PSI
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greg comfort walking 1
greg comfort walking 1
greg comfory walking 2
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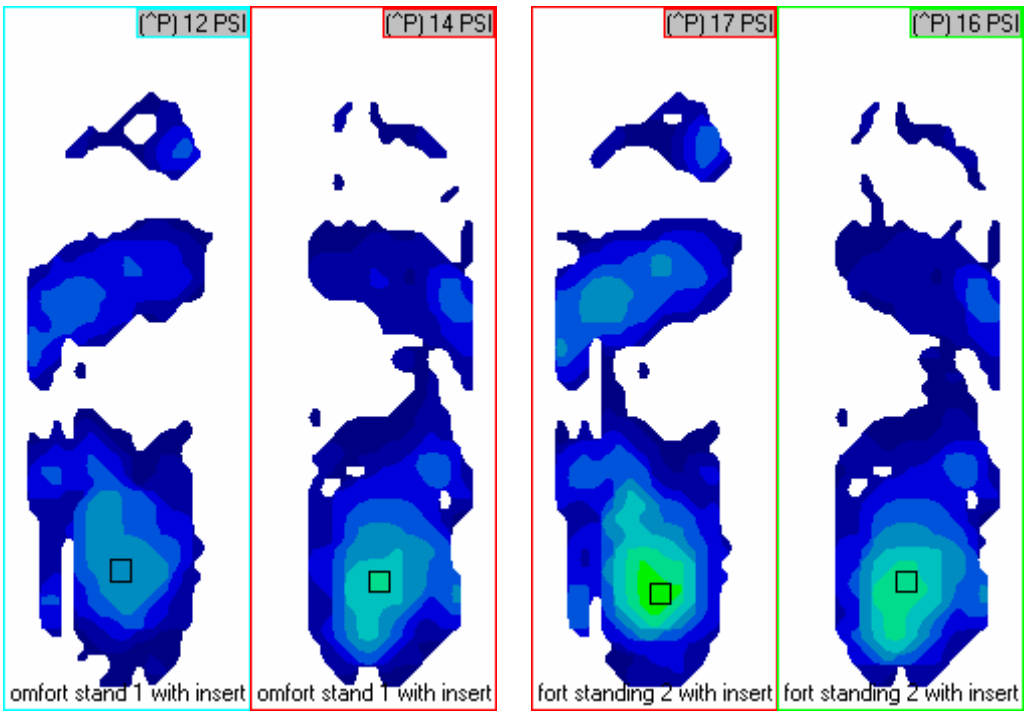
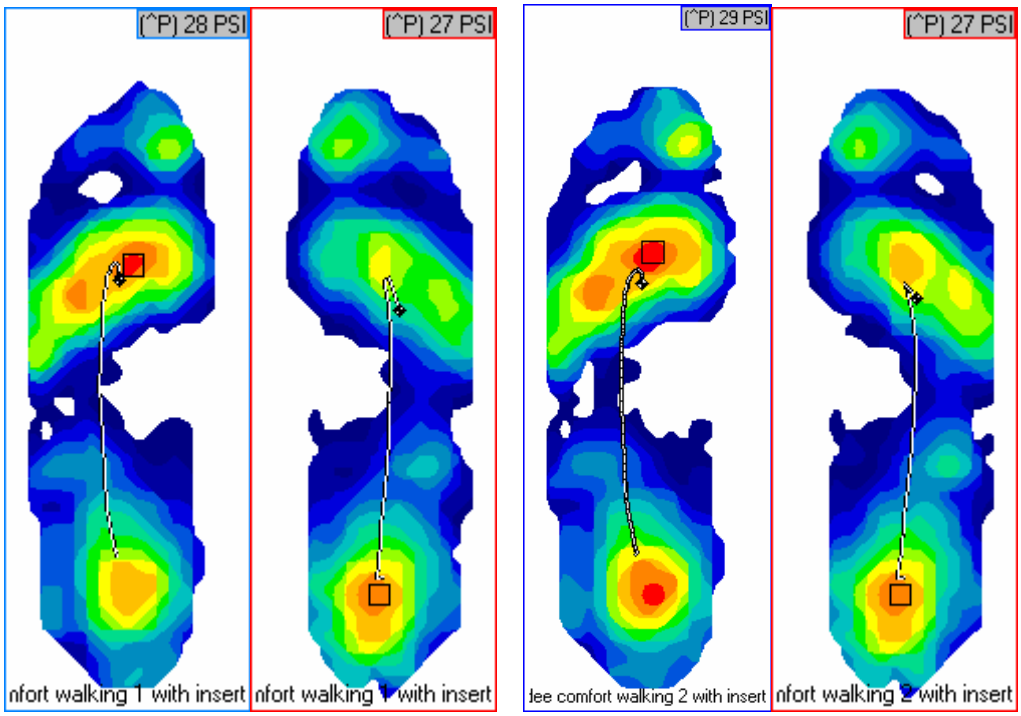
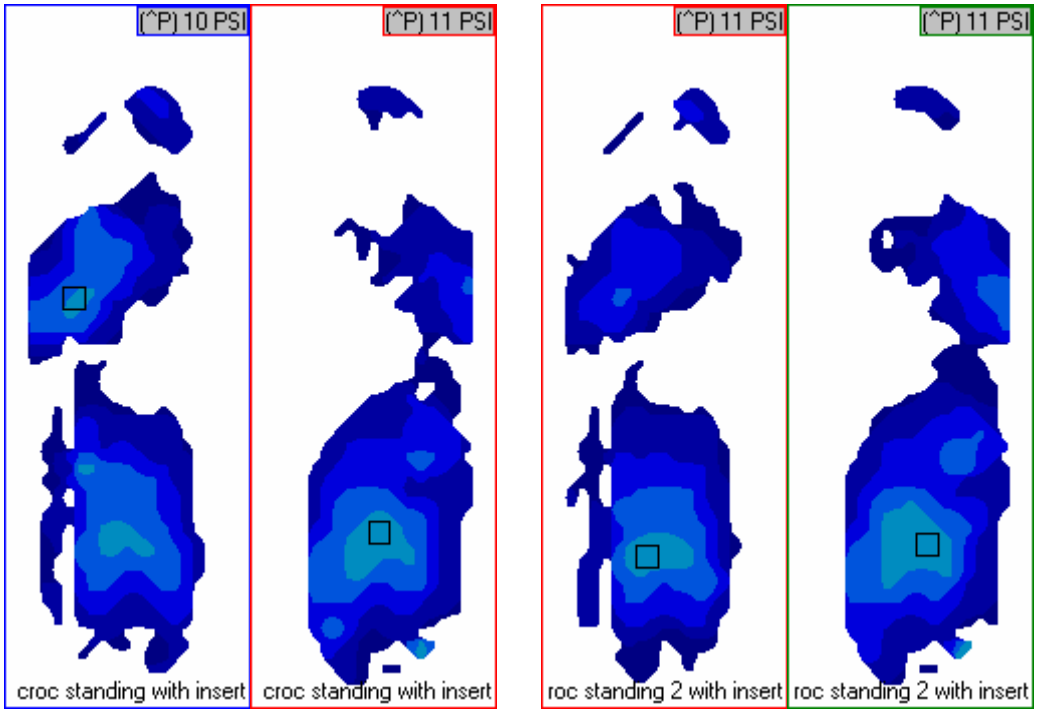
Subject 5 : Female : Size 9



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croc standing with insert
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roc standing 2 with insert
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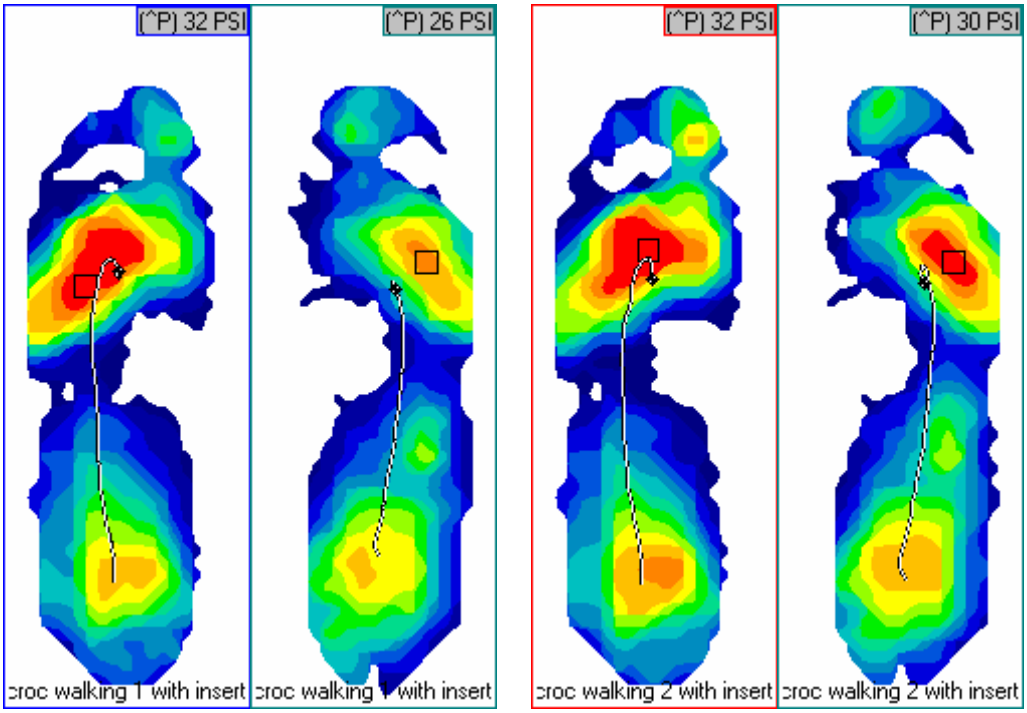
roc standing 2 with insert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croc walking 2 with insert
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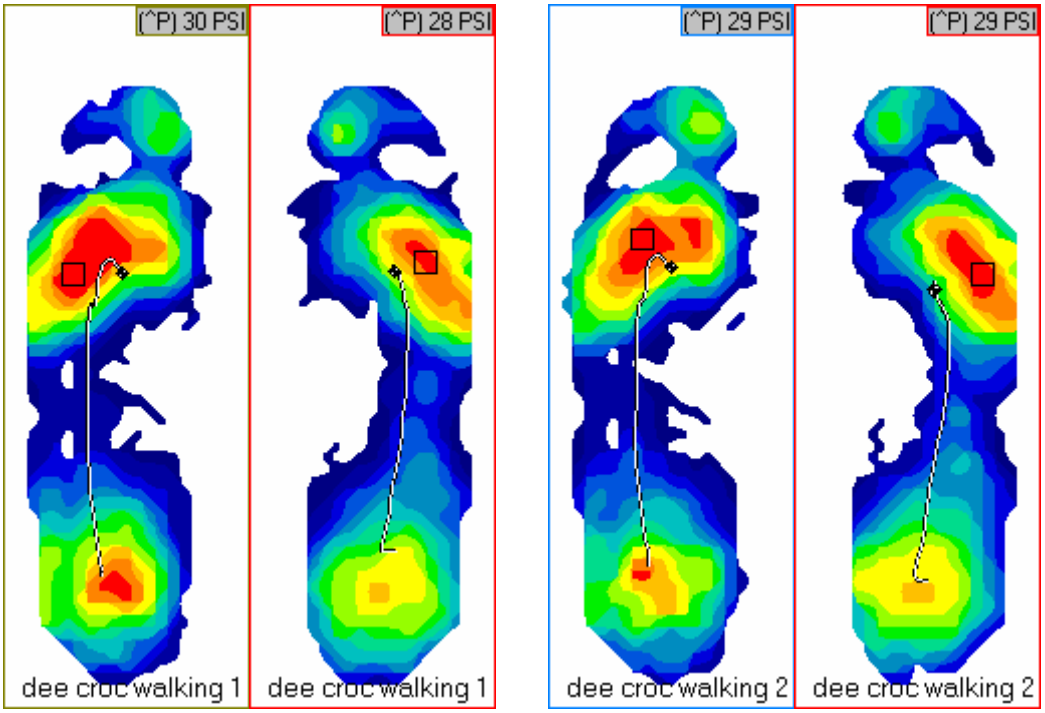
croc walking 2 with insert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(^P) 29 PSI
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dee croc walking 1
dee croc walking 2
dee croc walking 2