AQUANEX

HYDRODYNAMIC MEASUREMENT SYSTEM

USER MANUAL

Models DE8, TE1, DP2, DP8, DS2, DU2, DU2V, DU4V, TU2V
Version 4.3 for the Windows environment

Swimming Technology Research, Inc.
Richmond, Virginia

WARNING

Use of alternating current (AC) devices near water creates a known risk of electrical shock and serious injury. If you use the Aquanex system while any component (computer or computer interface) is connected to an AC power source, make sure that the AC and the wires and connections conducting the AC cannot come in contact with water. AC power sources should only be used in connection with a ground fault protection system. If you cannot be sure that the power source will not come in contact with water, power the system with a direct current (battery) power source.

Swimming Technology Research (STR) is not responsible for any injury sustained while using any component of AQUANEX. STR advises that AQUANEX only be used under the recommendation and supervision of a physician. A physical examination by a licensed physician is recommended before beginning any exercise or therapy program.

LIMITED WARRANTY

The Aquanex Hydrodynamic Measurement System is warranted to be free from defects in materials and workmanship. The warranty period is one year from the date of shipping to the initial purchaser. Swimming Technology Research (STR) has the option to repair or replace products returned to STR during the warranty period.

If it is necessary for an Aquanex system to be returned for service, a Return Material Authorization (RMA) Number must first be obtained from STR. STR reserves the right to direct the purchaser to return any components to the original manufacturer for servicing or replacement, according to the terms of any other warranties on that equipment. Any Computer Interface Unit (CIU) or Remote Sensor Unit (RSU) in need of repair must be returned directly to STR.

There are no user-serviceable parts in any Aquanex components. Any attempt to repair an Aquanex component voids the warranty. This warranty is void if failure of the system has resulted from accident or abuse. Use of any part of the Aquanex system in a manner inconsistent with the instructions listed in the documentation voids the warranty.

The responsibility of STR is limited to repair or replacement of the defective system component. STR does not accept liability for products not available due to defect or malfunction, any loss of data, or damages due to use of Aquanex software or hardware. STR makes no other warranties, either expressed or implied.

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PATENTS

U.S. Patent Nos. 4,654,010; 5,005,140; 5,258,927.

CONTENTS

OVERVIEW OF THE SYSTEM

AQUANEX is an acronym for "QUANtification of AQUAtic EXercise." The AQUANEX Hydrodynamic Measurement System provides instantaneous feedback about the intensity of the effort exerted during aquatic activities. The system detects the forces exerted on surfaces moved through the water and relays the information into a computer for analysis. The system allows for the continuous monitoring of an activity and displays the record of the exerted force on the computer screen as it is occurring. At any time during monitoring, the operator can begin to collect data which can be analyzed at the conclusion of data collection. An analysis of the data can be printed. The software also allows for the data to be saved on disk and later accessed. Data from multiple testing sessions can be listed and graphically compared.

Aquanex consists of the following components: Aquanex software, Computer Interface Unit (CIU or interface), and Remote Sensor Unit (RSU or sensor). The RSU senses the forces on surfaces and transmits the signal to the CIU. The CIU serves as an interface for a maximum of eight RSUs and relays the signals to the computer. The software controls the data processing and display.

There are several models of Aquanex. The model designation depends on the method of signal transmission from the sensors to the interface, the type of connection to the computer, and the number of simultaneously active channels. Aquanex sensors can transmit data to the interface via direct cable connection or telemetry signal. Aquanex can be configured to input data into the computer via the parallel port, serial port, or expansion card port. Aquanex systems have either one or eight simultaneously active channels.

Aquanex sensors are designated according to the method of signal transmission (Model D for direct cable and Model T for telemetry) and application type. Two types of Aquanex sensors (Type A and B) can be positioned on the body to measure many different types of aquatic exercises. Two other types of sensors (Type C and D) can be installed on aquatic exercise equipment. This versatility allows the operator to measure forces specific to the exercise objectives for a client. Performance can be recorded to evaluate and document improvement.

To activate the Aquanex system, the Aquanex software must be started from within Microsoft Windows. Once the program has been activated, the operator can view a graph of forces exerted by the client on the computer screen. The client can be outfitted with as many as eight RSUs at one time. Data can be collected on all eight channels simultaneously. Data on any two channels can be viewed during data collection and analyzed after data collection has been terminated. A data file may be saved or opened using the standard Windows dialog box.

The software is operated by selecting menu bar commands and command buttons. The command options are printed in this manual in a typeface similar to the Windows display (e.g. Continue refers to a Continue command button and File refers a menu bar command). Submenu selections are printed in this manual as File/Run indicating that the File menu bar selection must be activated to drop down the submenu selections from which Run can then be selected.

Following this overview is a section on measurement of aquatic movement which explains the quantification of aquatic movements using Aquanex. Reading the measurement section prior to using Aquanex should help in designing an exercise protocol specific to the needs of the client.

Other sections of this manual describe the software installation, system components and setup, and operating procedures. The section on data interpretation provides examples of characteristics typically observed during collection and analysis of data. The final sections of the manual summarize Aquanex operation and list other helpful information.

MEASUREMENT OF AQUATIC MOVEMENTS

One of the advantages of aquatic exercise is that a movement can be designed to target the specific needs for an individual. Aquanex can be used to measure virtually any type of aquatic movement. Measurements can be taken on any limb segment as well as on the trunk. The movements can conform to standard land-based exercises such as flexion-extension or adduction-abduction, or may be completely unique to the water modality with the directionality less conventional so that it is classified as positive-negative. Aquanex can quantify the movement and generate data representative of the change in performance over time.

Aquanex Variables

The are several variables generated by Aquanex that can be reviewed to determine progress. For both directions of each repetition the peak force, average force, impulse, and time duration can be displayed. Depending on the objectives for the client, any or all of the variables may be useful as criterion measures. The peak force is the greatest instantaneous force value in one direction for a repetition and is the most appropriate measure when muscular strength is the primary objective of a client's program. The average force for a repetition is the mean value for all the instantaneous force values for that repetition and will best indicate the strength throughout the range of motion, however large or small that range might be. Impulse is the summation of the instantaneous force values over time and best indicates the combination of strength and range of motion. The time duration values represent the interval between the beginning and ending of a repetition and may be useful to control the tempo of a movement, determine the consistency with which a movement pattern is replicated, or determine bilateral differences in the execution of the movement.

Measurement Variability

From previous research it has been determined that Aquanex produces reliable values for forces exerted in aquatic activities. Reliability coefficients are based on repeated trials of samples of subjects. For most clients, the force values will be similar from repetition to repetition. However, for any given client there can still be variability. The two most common reasons for variability are that a subject either diverges from the exercise protocol (with an incomplete range of motion or by turning the equipment or body surface so that it is not perpendicular to the direction of motion) or simply decreases intensity to rest. For these reasons, it is recommended that precautions be taken to fully describe the exercise protocol to ensure that the data are representative of the desired effort.

If a single repetition is needed for the criterion measure (e.g. one repetition maximum), one strategy is to have the client perform a low intensity repetition, followed by a moderate and finally high intensity repetition which would be used as the criterion measure. Following the high intensity repetition with one additional repetition will insure that the software can accurately determine the end of the high intensity repetition data. A progressively increasing intensity may eliminate the possibility of using a less than maximum effort as the criterion. If the client does not exert more force on the high intensity repetition than the moderate intensity repetition, then the client has obviously not adhered to the protocol.

Multiple repetitions will reveal the consistency with which a client exercises. Novelty of the movement and apprehension about being submerged are factors which can influence variability of the measurements. It is suggested that the data be examined for trends before selecting the criterion repetitions. Usually, a measurement that is trend-free is the most appropriate. As a client becomes accustomed to the water and the movement pattern, the variability will probably stabilize.

It is also important to examine the data for bilateral and anterior/posterior differences. If the differences are more or less than expected, there are several ways to verify the data. First, the data can be collected while the operator views the subject's movement pattern. Often, noncompliance with the protocol is observable. Second,

the exercise can be repeated testing one limb at a time. Third, the same exercise can be repeated with a modified protocol. Fourth, a similar exercise that targets the same muscles can be tested.

Movement Pattern Guidelines

Although virtually any aquatic movement can be measured with Aquanex, an exercise designed to adhere to the guidelines listed below will generate data that are representative of the desired movement pattern.

Qualify the movement protocol in terms of the resistive surface(s), joint action, range of motion, number of repetitions, and intensity of effort

Specify the movement pattern with enough detail so that the client can perform the desired movement and so that the directions result in the same movement being replicated at another testing session. The movement protocol should include qualification of the resistive surface(s), joint action, range of motion, number of repetitions, and intensity of effort. For example, qualify running in the water with the resistive surface of the upper leg, hip flexion and extension through 90° for 10 repetitions at a maximum intensity.

Maintain continuous motion

Continuous motion of any body segments to which sensors are attached will make the time duration calculations accurate with respect to the time that the segment was in motion in each direction. An exception would be if data are collected to determine that a segment is not in motion. If only one limb is of interest for a particular client, the sensor for the other limb can remain unplugged from the CIU. Continuous motion in some exercises may be facilitated by using flotation devices. For example, hip flexion and extension with extended legs may be accomplished by suspending the client in deep water with small floats under each arm.

Alternate movement in opposing directions

Alternatingly moving a body segment in opposing directions with the sensor perpendicular to the direction of motion will insure distinct force curves in both directions. If the action in only one direction is of interest, movement in the opposing direction can be performed at a much lower intensity. For example, if strengthening the elbow flexors are the only concern of the program, then the client can perform elbow extension at a low intensity that is only sufficient to generate a slightly greater force on the negative surface of the sensor than on the positive surface.

Balance horizontal forces with bilaterally opposing movements

For exercises that are performed in a plane parallel to the surface of the water, bilaterally opposing movements will limit unbalanced forces and minimize unwanted movement of the client during the exercise. For example, in a back floating position the client can abduct and adduct the arms or legs and remain in a relatively confined area.

Balance vertical forces with bilaterally alternating movements

For exercises that are performed in a plane perpendicular to the surface of the water, alternating movements of the limbs will neutralize the upward and downward forces on the body. For example, from a standing position with one elbow flexed and the other elbow extended so that the arm is alongside the body, simultaneously extend the flexed arm and flex the extended arm. Running in the water is another exercise which effectively balances vertical forces.

Restrain movements that cannot be balanced with opposing forces

Some exercise protocols and movement patterns such as swimming cannot be balanced with opposing forces, resulting in translational movement of the client across the body of water. These exercises can be effectively measured with the direct cable model of Aquanex by either tethering the client or positioning the client to exercise against a water flow such as in a flume or water treadmill. The client could also be measured freely moving about the pool with the telemetry model of Aquanex.

Avoid striking body segments or objects with sensor

Avoid exercises which require the client to move a body segment until making contact with another body segment or object. A sudden impact on a sensor is likely to cause a spike on the force graph which is not related to the client's performance. In cases in which it is preferable to define the exercise protocol or limit range of motion with other body segments or objects, instruct the client to begin to change direction of the motion just prior to making contact with the segment or object. For example, when adducting the arms, instruct the client to begin abduction prior to striking the body with the arms.

Review of Data

After data has been collected, a brief review of the data is recommended. The Data Graph window displays the complete record of the force curves and can be reviewed to determine that there is a distinct curve in both directions for each repetition. (For swimming, there should only be a curve in the positive direction with the force reading zero during the arm recovery.) Next, the Data Analysis window can be displayed to view the magnitude and consistency of the variables of interest. Finally, the Data Chart window provides a graphical display that may reveal trends not readily apparent from the other Data windows. If necessary, modify the protocol.

SOFTWARE INSTALLATION FOR MODELS DE8, DP8, DS2, TE1, and TP1

The Aquanex software must be installed on a computer that meets the minimum computer system requirements for Aquanex. A computer used as part of an Aquanex system must have a 386SX or higher CPU with a speed of at least 16 MHz and at least 1MB of free space on the hard disk drive. A VGA Video Display Adapter and 4 MB of RAM is also required. Software requirements are DOS 3.2 or higher and Microsoft Windows 3.1.

The Aquanex software runs under the Microsoft Windows environment. Only the most basic knowledge of Windows is necessary to operate Aquanex. If you are not familiar with the operation of Windows menu bars and controls, it is recommended that you review the Windows manual before proceeding with the software installation.

The setup program that is provided on the Aquanex diskette loads all the software necessary to run the Aquanex system. To install the software on your computer, first place the Aquanex diskette into your computer's 3.5 in. diskette drive.

If you are running Windows 3.1, open the Windows Program Manager. Select File/Run. The Run dialog box will open. On the command line type a:\setup and click the OK button. If you are running Windows 95 or 98, click the Start button on the task bar. Click the Run... option. The Run dialog box will open. The command line will read a:\setup.exe. Click the OK button.

The Aquanex setup screen will appear and designate C:\STR as the default directory. If the OK button is selected, the setup program will make the C:\STR directory and copy Aquanex files into that directory. Alternately, the C:\STR may be changed to any legitimate directory name.

After the installation has been completed, the AUTOEXEC.BAT file and the SYSTEM.INI file must be modified. The modifications can be made with any text editor. The Windows Notepad is recommended. The AUTOEXEC.BAT file is located in the root directory (C:\). Open the AUTOEXEC.BAT file and add the following lines to the end of the file:

```
SET CBDIREC=C:\WINDOWS\SYSTEM
PATH=C:\WINDOWS\SYSTEM
```

If there already is a PATH statement, don't add a new PATH, just add C:\WINDOWS\SYSTEM to the end of the existing PATH.

The SYSTEM.INI file is located in the C:\WINDOWS directory. Open the SYSTEM.INI file and add the following line in the [386Enh] section:

```
device=C:\WINDOWS\SYSTEM\CBUL.386
```

If the computer accesses the hard drive during data collection, set the size of the virtual memory to 0. This will generally only be necessary if you only have 4 MB RAM, or you are collecting data over several minutes. The virtual memory setting can be determined or changed in Windows. If you are running Windows 3.1, open the Windows Program Manager. Select the Main Window and open the Control Panel. Select the 386 Enhanced icon from the Control Panel options. Click the Virtual Memory... control in the 386 Enhanced window. Click the Change>> control in the Virtual Memory window. In the New Size input box enter 0. Click OK in the Virtual Memory window. Click Yes to set the swap-file type to None. Click Yes in response to "Are you sure you want to make changes to virtual-memory settings?" Finally, choose Restart Windows. If you are running Windows 95/98, click the Start button on the taskbar. Click the Control Panel option under Settings. Double click the System icon in the Control Panel Window. Select the Performance tab. Click the Virtual Memory button and click the option to Disable Virtual Memory.

SOFTWARE INSTALLATION FOR MODELS DU2, DU2V, AND TU2V

The minimum computer requirements are a Pentium 4 running at 1 GHz with Windows XP with Service Pack 3. If you are installing under Windows 7, a 64-bit dual core CPU is required. Use at least Aquanex V4.0 with DU2V Model 19 or higher.

The default values are strongly recommended. If a message appears during installation warning that the driver is not digitally signed, select the option to continue installation.

For Model 21: If installing under Windows 8 or 10, disable the digital signature: Click the Settings Charm/Change PC Settings/Update&recovery/Recovery/Restart/Troubleshoot/Advanced options/Startup Settings/Restart/F7. The PC will then reboot.

Insert the Installation CD into the CD drive.

Open the Video Drivers folder on the CD and run setup.exe. (If your interface is Model 15 or 18 and setup.exe will not run, right click on setup.exe and select *Properties*, *Compatibility*, *Run this program in compatibility mode for Windows XP with Service Pack 2*.) Follow the program directions.

For Model 18 to 21: Open the DataDrivers1 folder on the CD and run iUSBDAQDriver2010.exe. Follow the program directions. Go to Device Manager, right click on iUSBDAQ, select Property/Update Driver and point to the path for hymchpusb.inf.
For Model 22: Open the DataDrivers folder and run Labjack-2010-02-01.exe. Follow the program directions.

Run setup.exe from the root directory on the CD. Follow the program directions. Copy capture.avi into the C:\ directory.

The first time that the video and data USB cables from the CIU are connected to the computer, a "Found New Hardware" message will appear. Follow the directions of the Wizard. If you are installing Model 18 to 21, do not select the auto install option when you plug in the data cable. Point to the folder where the data drivers are located (DataDrivers1 for Windows7 and DataDriver2 for Windows8).

SYSTEM COMPONENTS AND SETUP

Prior to connecting and operating Aquanex, it is recommended that you refer to the WARNING on 2.

The components of Aquanex must be connected prior to use. An Aquanex system consists of software, an interface (CIU), and at least one sensor (RSU) which are used with a computer that meets the minimum requirements specified in the section on SOFTWARE INSTALLATION. The CIU is connected to the computer. Depending on the model, the RSUs are either *directly* connected to the CIU with a cable (Model D) or send a *telemetry* signal to the CIU (Model T).

Computer Interface Unit (CIU)

The computer interface unit (CIU) transmits the signal from the sensor(s) to the computer. The different models are designated by two letters and one number (i.e. Model XX#), where the first letter indicates the signal transmission type from the sensor(s), the second letter specifies the connection to the computer, and the number represents the maximum number of simultaneously active channels. The signal can be transmitted by either a *direct* cable connection (Model DX#) or by a *telemetry* signal (Model TX#). The CIU can be connected to a computer by the *parallel* port (Model XP#), the *serial* port (Model XS#), or the socket of an *expansion* card (Model XE#). The CIU can have a maximum number of simultaneously active channels of *1* (Model XX1) or *8*

(Model XX8). There are currently five models of the interface available: DP8, DE8, DS1, TP1, and TE1. The DE8 was formerly called the D1 and the TE1 was formerly the T1.
On the front side of each interface there is a socket to connect the CIU with the computer via a data cable. Models DP8, DS1, and TP1 also have a power cable that connects to the computer. On the back of the Model DX# interfaces there are either one, two, four, or eight sockets with four pins for connecting sensors.

Model DE8 (CIU/DE8), formerly Model D1 (CIU/D1)

An expansion card comes with the DE8 and is installed in the computer. The card is an IBM PC/XT/AT compatible and requires only a one-half size card slot (8-bit). Install the circuit board in an expansion slot in your computer according to the instructions in the computer manual. In the event that you have questions, the technical assistance department of the manufacturer your computer is the best source of information.

The CIU/DE8 connects to the socket of the expansion card using a data cable with DB37 connectors. One female connector plugs into the CIU and the other female connector plugs into the socket of the circuit board that you installed in your computer.

Model DP8 (CIU/DP8)

The CIU/DP8 connects to the parallel port of the computer using a data cable with DB25 connectors. The female connector plugs into the CIU and the male connector plugs into the parallel port (LPT1) of the computer. The power cable of the DP8 has a six pin plug that connects to a PS/2 mouse port.

RSU Connections to CIU Models DP8 and DE8

On the back side of the interface there are eight, four pin sockets for connecting sensors. The RSU plugs are keyed to fit in the CIU sockets in only one way.
All four types of sensors (Type A, B, C, or D) can be connected to the interface, but they must be plugged into the appropriate socket. The 8 sockets on the CIU are each labeled as a different channel (1 - 8) and are programmed for different RSUs. The following table lists the proper connections for each channel. If the RSUs are not properly connected to the CIU, invalid readings may result.

Type C and D sensors must be connected to the channel for the body part on which the sensor is worn. Type C and D sensors are usually installed in handheld equipment (aquatic barbells or hand paddles) or on fins. Sensors installed in equipment for the hands or feet are connected to channels 1 and 2.

RSU/CIU Connections for Eight Channel CIUs (CIU/DP8 & CIU/DE8)				
Channel	**RSU Type**	**Arm/Trunk**	**Leg/Trunk**	**Side**
1	A	Hand	Foot	Left
2	A	Hand	Foot	Right
3	B	Lower Arm	Lower Leg	Left
4	B	Lower Arm	Lower Leg	Right
5	B	Upper Arm	Upper Leg	Left
6	B	Upper Arm	Upper Leg	Right
7	B	Trunk	Trunk	Left
8	B	Trunk	Trunk	Right

Model DS1 (CIU/DS1)

The CIU/DS1 connects to the serial port of the computer using a data cable with DB9 connectors. The male connector plugs into the CIU and the female connector plugs into the serial port (either COM1, COM2, COM3, or COM4) of the computer. The com port selected for use with Aquanex must be designated in the Customize window under the Model menu bar option. The power cable of the DP8 has a six pin plug that connects to a PS/2 mouse port.

On the other side of the interface there is a four pin socket for connecting sensors. All four types of sensors (Type A, B, C, or D) can be connected to the interface.

Model TE1 (CIU/TE1), formerly Model T1 (CIU/T1)

An expansion card comes with the TE1 and is installed in the computer. The card is an IBM PC/XT/AT compatible and requires only a one-half size card slot (8-bit). Install the circuit board in an expansion slot in your computer according to the instructions in the computer manual. In the event that you have questions, the technical assistance department of the manufacturer your computer is the best source of information.

The CIU/TE1 connects to the socket of the expansion card using a data cable with a DB37 connector on one end and a phono plug on the other. The female DB37 connector plugs into the socket of the circuit board that you installed in your computer. The phono plug on the other end of the cable plugs into the socket of the interface labeled "DATA." To ready the unit to receive data, completely extend the antenna and toggle the switch to the "ON" position.
If the battery needs to be charged, plug the charger into a standard household socket. Connect the phono plug with the socket labeled "POWER" on the back of the CIU/T1. Recharging requires about 8 hours. The unit can also be operated with AC when the recharger is connected.

Model TP1 (CIU/TP1)

The CIU/TP1 connects to the parallel port of the computer using a data cable with DB25 connectors. The female connector plugs into the CIU and the male connector plugs into the parallel port (LPT1) of the computer. The power cable of the DP8 has a six pin plug that connects to a PS/2 mouse port. To ready the unit to receive data, completely extend the antenna and toggle the switch to the "ON" position.

Models DU2 and DU2V (CIU/DU2 and CIU/DU2V)

Connect the Video Output USB connector to a USB port on the computer. Wait until the hardware is recognized by Windows.

Connect the Data Output USB connector to a USB port on the computer. Wait until the hardware is recognized by Windows.

It is recommended that the same USB ports be used for the video and data outputs every time the interface is connected to the computer.

On the other side of the interface there are two four pin sockets for connecting sensors. All four types of sensors (Type A, B, C, or D) can be connected to the interface.

Models TU2V (CIU/TU2V)

Connect the Video Output USB connector to a USB 2.0 port on the computer. Wait until the hardware is recognized by Windows.

Connect the Data Output USB connector to a USB 2.0 port on the computer. Wait until the hardware is recognized by Windows.

It is recommended that the same USB ports be used for the video and data outputs every time the interface is connected to the computer.

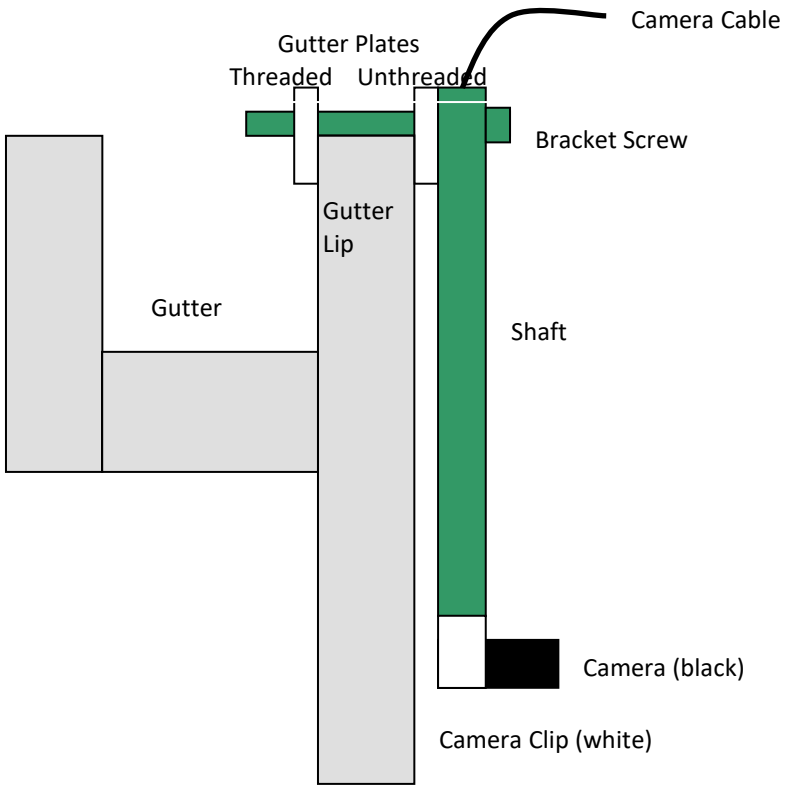
Remote Camera Unit (RCU/DUC)

Install the underwater camera at the center of the end of the lane that will be used for data collection.
The bracket consists of a shaft, camera clip, bracket screw, 2 unthreaded gutter plates, and 1 threaded gutter plate. Screw the threaded gutter plate on the bracket screw until the gutter plates are about the same distance apart as the gutter width. Lower the bracket onto the lip of the gutter so that one gutter plate is on each side of the lip.Tighten the threaded gutter plate until the gutter plates are secure against the gutter lip.

Don't overtighten the threaded gutter plate. After the threaded gutter plate is tight, check that the bracket screw is parallel to the top of the gutter lip and that the shaft is parallel to the wall. To adjust the aim, the camera can be rotated in the clip and the clip can be laterally rotated.

There are many different designs of swimming pool walls and gutters. In some cases, a second unthreaded gutter plate is necessary to make the camera shaft hang straight. If the bracket will not fit your pool as shown above, contact us for possible modifications.

Connect the 12 volt DC power supply (8 AA batteries) to the camera cable. Connect the RCA connector on the camera cable to the Video Input on the interface (CIU/DU2V or CIU/TU2V).



The newest version of the camera bracket shaft is expandable. The depth of the camera below the gutter rim is adjusted by unscrewing the wingnuts on the front of the bracket, sliding the inner bracket down, and screwing the wingnut into aligned holes in the inner and outer brackets. For a pool with a longer distance between the gutter rim and the water, add the bracket extension. Thread the camera sockets through the shaft of the bracket extension with the large hole end of the bracket last. Secure the bracket extension with a wingnut.

If the standard bracket is not extended, it will position the camera about 10 in (25 cm) below the gutter rim. If the standard bracket is completely extended, it will position the camera about 16 in (40 cm) below the gutter rim. If the bracket extension is added, it will position the camera about 22 in (55 cm) below the gutter rim

Remote Sensor Unit (RSU)

Aquanex measures the forces exerted during aquatic exercises with different types of sensors (RSUs) attached to the resistive surfaces that are moved through the water. There are four types of sensors that can be used with Aquanex (A, B, C, and D). All four types of sensors are available for both models (RSU/D and RSU/T).

RSU/Ds for Model DX# interfaces (DE8, DP8, and DS1) directly connect to the interface with a cable. After an RSU/D plug has been inserted into the CIU socket, tighten the lock nut so that the plug may not be inadvertently disconnected during operation. It is recommended that all the RSU/D cables be restrained between the CIU and the client, so that the client may not be able to completely extend the RSU/D cables and pull the CIU from its testing position.

RSU/Ts for Model T interfaces have a cable between the sensor element and the transmitter. The switch must be toggled to the "ON" position to transmit data to the interface. Only one sensor may be turned on at a time. A standard 9 volt battery powers the transmitter and needs to be periodically replaced.

RSU Type A

The Type A sensor is designed to be worn on the hand or foot. Place the sensor between the client's third and fourth fingers, so that the stem is positioned between the fingers. The main body of the sensor will rest between the third and fourth fingers on the back of the hand. The flange will hold the sensor in place on the palmar side. Although not generally necessary, a rubber band or strap can be used to hold the third and fourth fingers together. If the cable interferes with the exercise, it can be secured under a strap worn around the wrist or upper arm, or looped under a belt that is worn around the waist.

When testing swimmers, it is recommended that the cable be secured to the swimmer's arm at both the wrist and upper arm. A rubber band threaded through itself provides a quick and easy means for cable management. The cables lead from the swimmer's waist to the side of the pool perpendicular to the direction of the swim to keep the cables free of the kicking action. This arrangement is suitable for both tethered and free swimming. An extra precaution during free swimming is to have the swim terminate at a wall to prevent placing undue stress on the cable or interface.

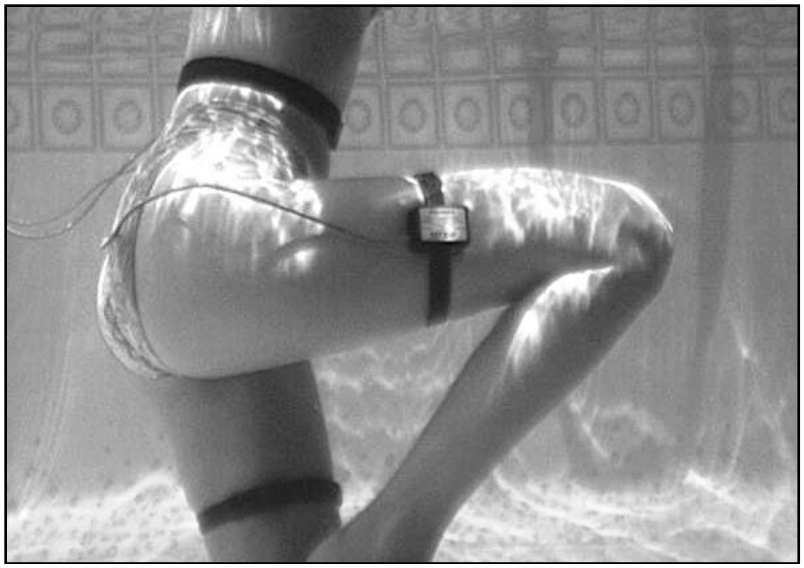
When the Type A sensor is worn on the foot, position the main body of the sensor on the top (dorsal) side of the foot so that the stem can extend between the second and third toes with the flange resting against the bottom (plantar) side of the foot.

The Model T sensors are worn in a similar fashion to the Model D sensors. It is important to position the transmitter case so that it stays at the surface. The belt around the swimmer's waist may need to be adjusted. It is also important to keep at least part of the antenna above the surface. Instruct swimmers to stay at the surface when using a Model T unit. Pushing off below the surface and performing turns is not recommended. Submerging the unit can void the warranty.

RSU Type B

The Type B sensor can be strapped to the upper or lower arm or leg. Two Type B sensors can be snapped together to fit around the trunk. The sensor should be positioned in the middle of the body segment so that the sides with the ports (the sides that are labeled "Positive" and "Negative") are perpendicular to the direction of movement. Orient the sensor so that the positive port faces the positive, flexion, or adduction direction and the negative port faces the negative, extension, or abduction direction. Adjust the strap so that the sensor will stay in place throughout the range of motion of the exercise. If the cable interferes with the exercise, it can be looped under a belt that is worn around the waist.

The Type B sensor can be positioned as shown below to measure forces during hip flexion and extension. After the sensor has been attached, examine both sides to check that the ports are positioned to measure forces perpendicular to the direction of motion of the exercise.

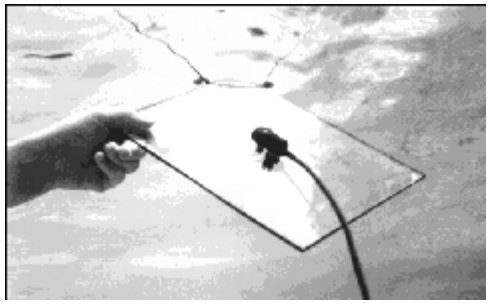


RSU Type C

Type C sensors are custom installed on aquatic exercise equipment by STR. A Type C sensor requires a minimum space (cavity) of 1.25 in. x .75 in. x .5 in. (32 mm x 19 mm x 13 mm) and can be installed in equipment manufactured by several companies. Contact STR for more information.

RSU Type D

Type D sensors can be installed by the user on hand paddles, fins, and other aquatic exercise equipment that meets the installation specifications. An RSU Type D can be installed on equipment surfaces that are flat, less than .75 in. (19 mm) thick, and have unrestricted water flow on both sides. One mounting hole with a diameter of 3/8 in. (10 mm) must be drilled in the surface. It is best to mount the sensor away from the edge of the surface and so that fingers or toes will not obstruct either port. The sensor can then be secured in place with an O-ring.



Positioning sensors on the body

Since forces are measured perpendicular to the ports of the RSUs, ensure that the ports are positioned perpendicular to the direction of movement of the sensor throughout the range of motion. If the port is oriented at an angle to the direction of movement, the force measured by Aquanex may be less than that actually exerted by the performer. Rotation of the body segment to which the sensor is attached can also result in a decreased force.

The sensors can be attached to provide measurements on many types of exercises. The table below lists the recommended configuration for many typical movements. For all configurations, it is important to ensure that the sensor is positioned in the middle of the body segment that is used as the resistive surface.

Sensors Locations for Typical Exercise Movements

Articulation	Joint Action	Segment	Surface	Channels	RSU Type
Wrist	Flexion/Extension	Hand	Palmar/Dorsal	1 & 2	A
Elbow	Flexion/Extension	Hand	Palmar/Dorsal	1 & 2	A
Elbow	Flexion/Extension	Lower Arm	Lateral	3 & 4	B
Shoulder	Flexion/Extension	Hand	Palmar/Dorsal	1 & 2	A
Shoulder	Flexion/Extension	Lower Arm	Lateral	3 & 4	B
Shoulder	Flexion/Extension	Upper Arm	Lateral	5 & 6	B
Shoulder	Abduction/Adduction	Hand	Palmar/Dorsal	1 & 2	A
Shoulder	Abduction/Adduction	Lower Arm	Medial or Lateral*	3 & 4	B
Shoulder	Abduction/Adduction	Upper Arm	Posterior	5 & 6	B
Ankle	Flexion/Extension	Foot	Plantar/Dorsal	1 & 2	A
Knee	Flexion/Extension	Foot	Plantar/Dorsal	1 & 2	A
Knee	Flexion/Extension	Lower Leg	Lateral	3 & 4	B
Hip	Flexion/Extension	Foot	Plantar/Dorsal	1 & 2	A
Hip	Flexion/Extension	Lower Leg	Lateral	3 & 4	B
Hip	Flexion/Extension	Upper Leg	Lateral	5 & 6	B
Hip	Flexion/Extension	Trunk	Lateral	7 & 8	B
Hip	Abduction/Adduction	Lower Leg	Posterior	3 & 4	B
Hip	Abduction/Adduction	Upper Leg	Anterior	5 & 6	B

*Medial and lateral surfaces of the lower arm are relative to the normal position (arm resting along the side of the body with the thumb pointing forward).

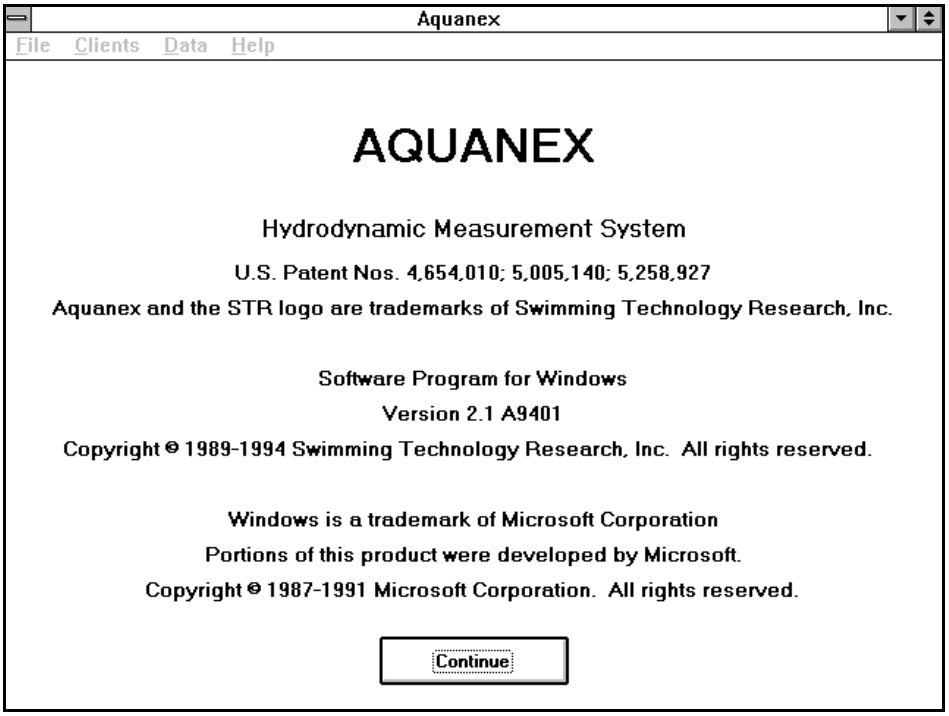
It is important to ensure that both the location of the sensors and the protocol of the exercise are replicated from trial to trial. Measurement of the body segments may be necessary to position the sensor at the middle of the segment for each trial. The protocol of the exercise should be qualified for the performer in terms of the resistive surface(s), joint action, range of motion, number of repetitions, and the intensity of the effort (as explained in the section "Movement Pattern Guidelines"). The sensors and body segments should be submerged throughout the range of motion of the exercise.

If the cable interferes with the movement, it can be secured to a limb with a material which will hold the cable in place and not cause discomfort to the client (e.g. rubber band, velcro). It is also important to ensure that there is adequate slack on the cable leading to a sensor. Avoid exerting force on the cable connection to the sensor which could either distort the force values or damage the sensor.

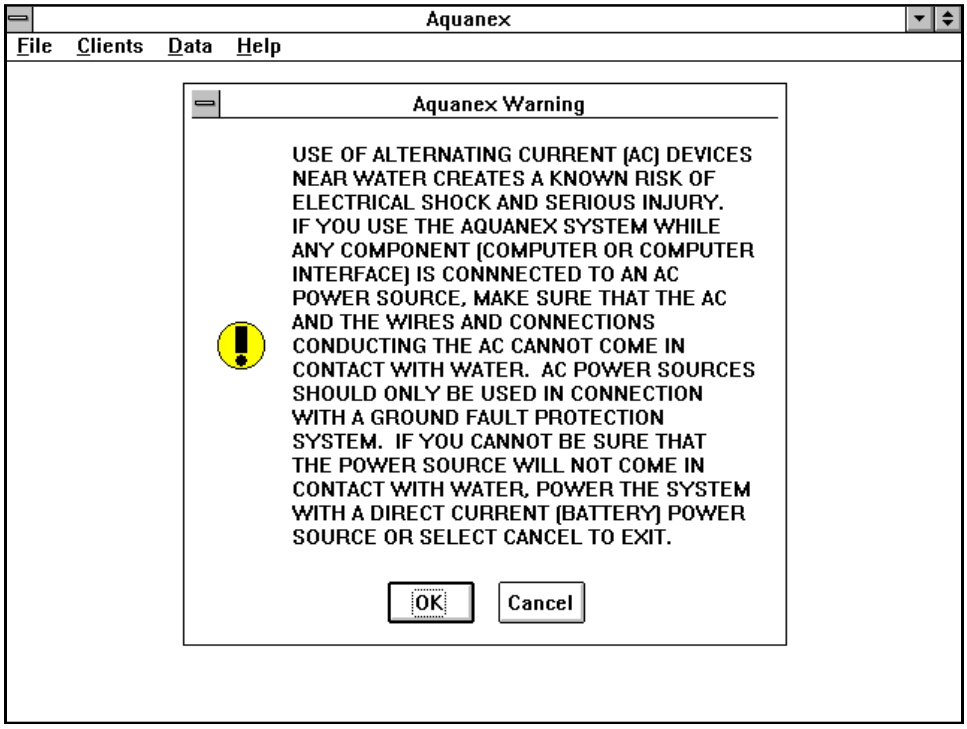
OPERATING PROCEDURES

After the Aquanex software has been installed with the setup program, the Aquanex icon can be found in the Aquanex group window. If the Aquanex group window is not visible, click the Window option on the Program Manager menu bar and select Aquanex.

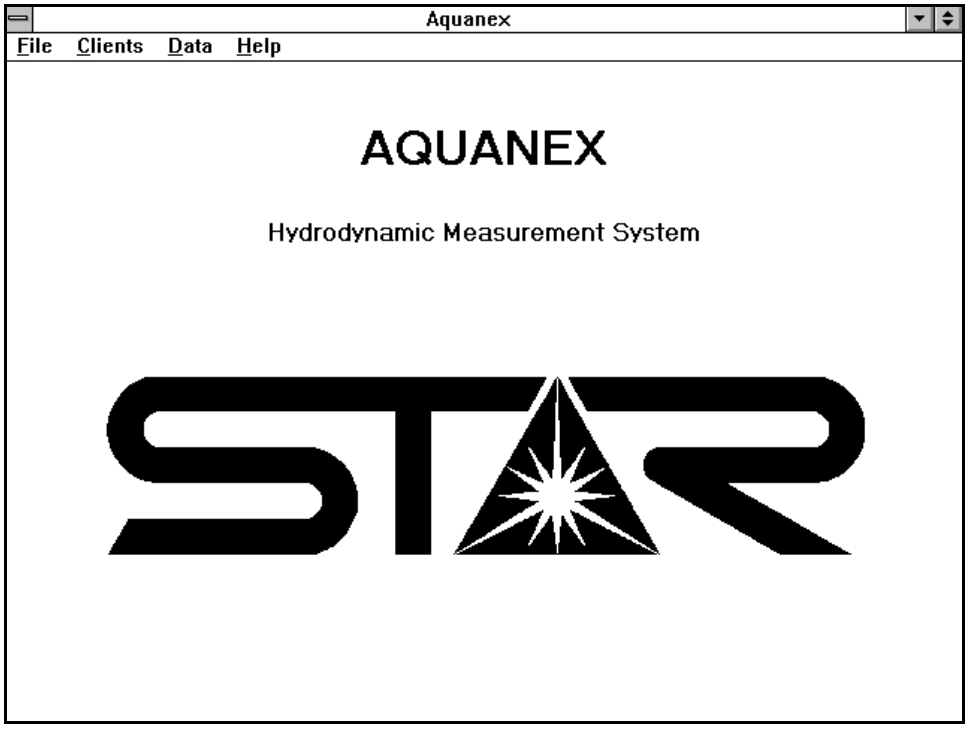
When the Aquanex icon is selected by double clicking, the program is activated. (If your interface is Model 18 and your operating system is Vista, right click on Aquanex.exe and select *Properties*, *Compatibility*, *Run this program in compatibility mode for Windows XP with Service Pack 2* and *Run as Administrator*.) The program will start to run and display the title screen. In addition to the patent and copyright information, the title screen displays the version number. A copy of the full version of the software has a version number that ends with four digits. If the version number on the screen has the letter "D" at the end (e.g. V 2.0 C9307D) then it is a demo version. If there is a "T" at the end of the version number, then it is a trial version. The demo version has all the functions of the full version with the exception that a maximum of five clients can be added to the client list. The trial version is designed for installation of the Aquanex system on a trial basis.



When the title screen is first displayed the menu bar selections will be gray, indicating that they are not yet activated. After the Continue command button has been clicked, the Aquanex Warning appears on the screen. If you cannot ensure compliance with the warning, click the Cancel button to exit from Aquanex. If the system configuration complies with the warning, click OK.



The STR logo will appear and the options on the menu bar will be black indicating that they have been activated. The operator can then choose a selection by pointing the cursor to the desired menu bar option and clicking the left mouse button, or by pressing the key for the underlined letter.

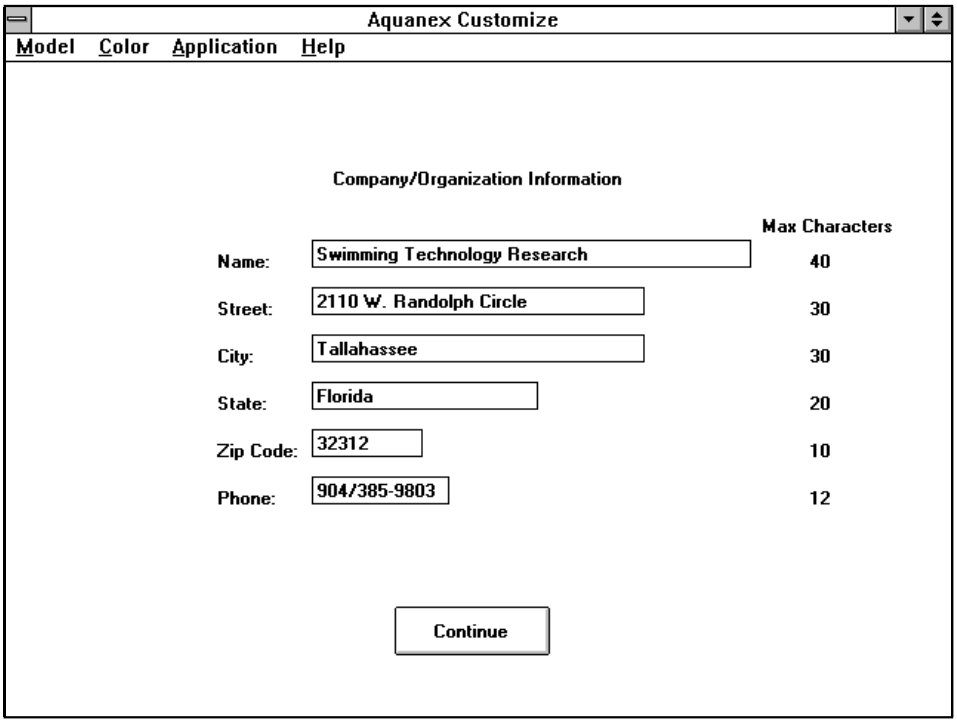


There are four main options on the menu bar that may be selected from this point: File, Clients, Data, and Help. The File and Data selections have submenus. The Clients and Help selections do not have submenus. The File option has submenu selections to open windows to customize the system and open and save files. The File command also has options to print reports and exit from the Aquanex program. The Clients option opens the Client window for adding, deleting, editing client information, and selecting clients to be tested. Information about each client can also be entered. The Data command has submenu selections to open windows to monitor, graph, analyze, compare, or chart data. The Help option opens the Help window.

From the STR logo window it is recommended that the operator first choose File/Customize so that Aquanex reports will include the name, address, and phone number of the company or organization. The operator can then choose Clients, add a client to be tested, and proceed to the Data Monitor window.

Customizing the System - File/Customize

Selecting File/Customize will open the Customize window. Input the information in the boxes shown below and select the Continue button. Once the information has been entered, any reports printed from either the Data/Analysis or Data/Comparison windows will include the company/organization information. Since the information will be saved in an Aquanex file, the company/organization information only needs to be entered one time. You only need to open the Customize window again if you wish to change the information.



The maximum number of characters that can be entered is listed to the right of each data box. The name has a maximum of 40 characters, street and city are limited to 30 characters, and the state data box has a maximum of 20 characters. The zip code can be ten characters long which allows for a hyphen between the first five and last four digits (e.g. 12345-6789). The phone data box allows a maximum of 12 characters with space for a slash (/) between the area code and the first three digits of the number and a hyphen between the first three and last four digits of the number (e.g. 123/456-7890).

The Model option on the menu bar allows the user to configure the system for the DE8 (D1), DP8, DS1, TE1 (T1), or TP1. If the DS1 is selected, the operator must also identify the computer com port (COM1, COM2, COM3, or COM4) used for the connection of the interface data cable.

The Color option opens the standard Windows color dialog box. There are four submenu options under Color: Windows Background, Windows Foreground, Data Background, and Data Foreground. The Data Background changes the color of the background of all the boxes used to input or display data. The Data Foreground command changes the color of the text in the data boxes. The Windows Background changes the color of the background of the remaining features in the windows. The Windows Foreground

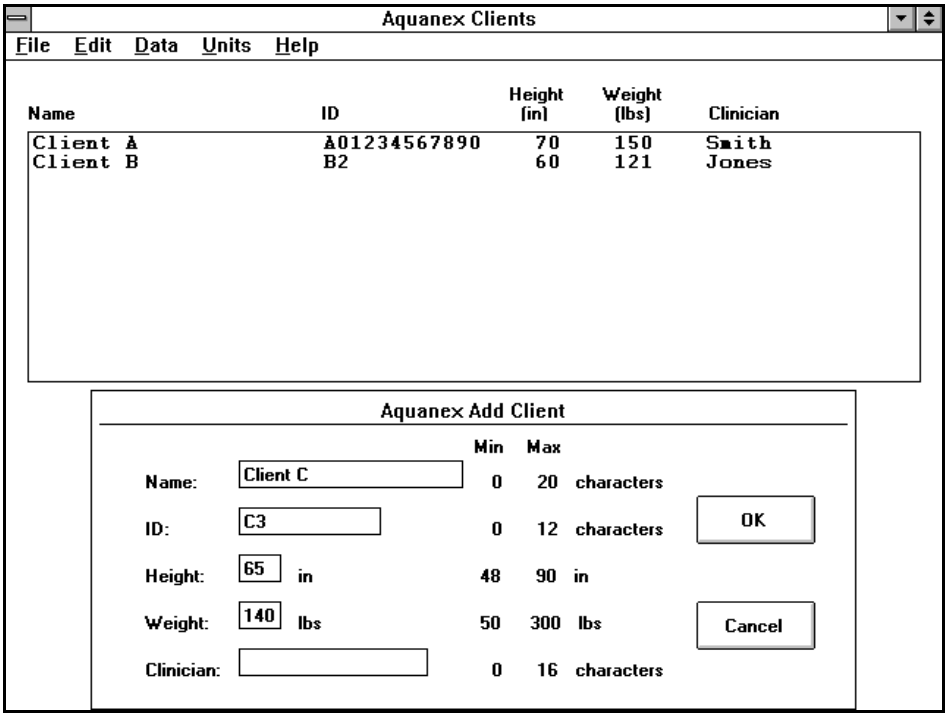
changes the color of the text of the remaining features. To maintain contrast on video displays and printouts, the color menu bar commands will not change any colors in the Data Chart window. The best contrast on all printed images will be achieved with the foregrounds for both the data and windows set to black and the backgrounds set to white, which is automatically adjusted by selecting the Black on White option.

The color of the menus bars, scroll bars, and command buttons can be changed from the Color option in the Control Panel of the Main Window in the Windows Program Manager. Additional information about changing the colors using the Windows Color dialog box can be found in the Windows *User's Guide*.

The Application command drops down the options of Exercise and Swimming. For any exercise or therapy program select the Exercise option. The Swimming option is only intended for testing the four competitive swimming strokes.

Entering Client Information - Clients

Before any data can be collected on a client, the client must first be selected (or added) to the Clients window. Selecting Clients on the menu bar opens the Clients window. From the menu in the Clients window click Edit/Add Client to add a client to the list. The Add Client window will appear to allow entry of the new client's data.



Client information can be entered by clicking the desired data box and typing the value. The minimum and maximum values are displayed to the right of the data boxes. For the name, ID, and clinician the minimum of characters is 0 (i.e. the information is optional). The maximum number of characters is 20 for name, 12 for ID, and 16 for clinician. The client's height and weight must be entered. The minimum values are 48 in. (122 cm) for height and 50 lbs. (23 kg) for weight. The maximum values are 90 in. (229 cm) for height and 300 lbs. (136 kg) for weight. After the values have been entered, click OK to return to the Clients window. The maximum number of clients that can be added to the Clients window is 500.

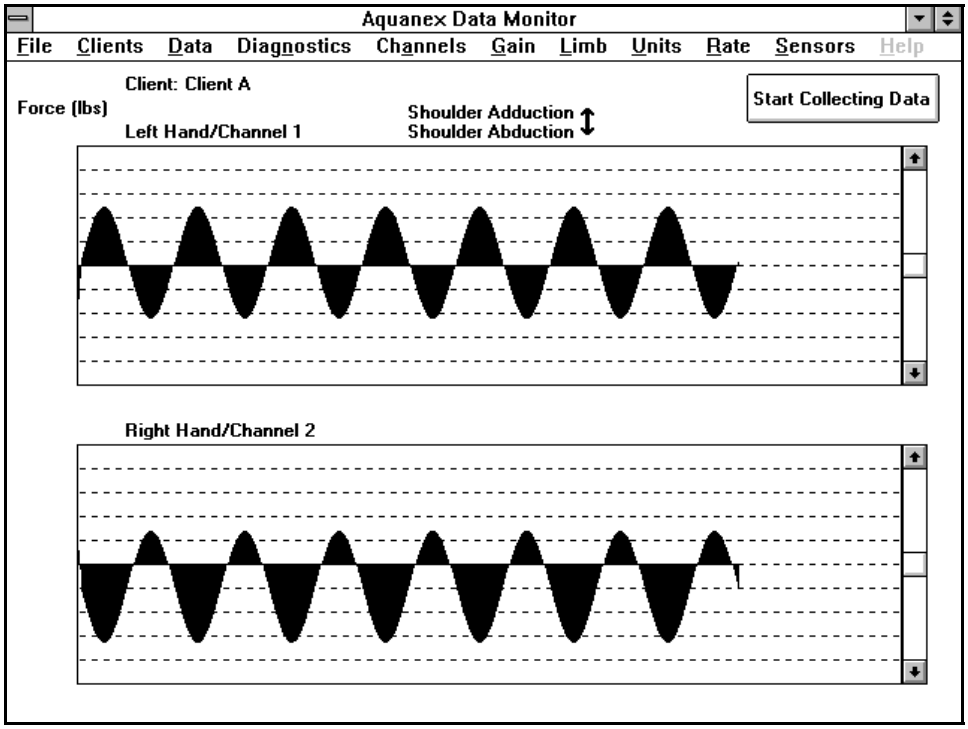
The displayed units for the clients' height and weight can be changed from metric to US by selecting Unit/US from the menu bar. Once a client's name has been highlighted by pointing to the client's name in the list and clicking, select Data/Monitor to view the client's performance.

To edit the data on a client first highlight the client's name, then select Edit/Edit Client from the menu bar. The Edit Client window will appear and list the client's information in data boxes. The Edit Client window is very similar to the Add Client window, the only difference being that it doesn't have a Cancel button. While a client is being edited, the client is temporarily deleted from the data box in the Client window. Even if the client's name is changed, the client will be alphabetically inserted into the data box.

To delete a client from the client list, point to the client's name and click the left mouse button. Once the client's name has been highlighted, select Edit/Delete Client from the menu bar.

Monitoring Data - Data/Monitor

When Data/Monitor is selected, the screen changes to a graphical display of the selected channels. The program will monitor the channels indefinitely, without collecting any data. During this monitoring process, the operator has the opportunity to make adjustments in the display before beginning data collection. Adjustments in the display may be made to use different types and series of RSUs, to monitor different RSUs, to account for the sensitivity of the RSUs, to vary the sampling rate, to center the baseline, and to optimize the gain so that the forces being monitored are easy to read on the screen. The Data Monitor window displays the client's name, the force units, the surface to which the sensors are attached, the active channel numbers, and the joint action.



Changing the sensor information

Aquanex sensors can be used to measure forces exerted against body segments or exercise equipment. Type A and B sensors are used to measure forces on the body. Type C and D sensors are installed on equipment. Pull down the Sensor menu and make sure that the appropriate type is checked for each channel pair that is in use. If you click the Type C and D menu selection, a surface area input box will appear near the top of the window. The surface area of the equipment must be entered in this box. Valid surface area values are 100 to 3000 sq cm (16 to 465 sq in). The force values on the side of the graph will change as the surface area is input.

There are four series of sensors that operate with Aquanex: Series 25, Series 40, Series 80, and Series 90. The higher series sensors are more sensitive. A series indicator is printed on each sensor label directly after the type. For example, a sensor labeled Type A80 is a Type A, Series 80 sensor. Type A, C, and D sensors for Model DX# interfaces are labeled on the connector and Type B sensors are labeled on the sensor enclosure. All sensors for Model TX# interfaces are labeled on the transmitter. Select the proper series from the selections under the Sensor command on the menu bar before monitoring data. Series 90 sensors ship with Model 18 or higher.

The type of exercise or swimming stroke can be indicated by using the Sensor menu. If the Exercise application option was selected, then select the joint and the joint action for each pair of sensors. The joint options that are activated depend on the body segment to which the sensors are attached. For example, if the sensors are worn on the hand, the Wrist, Elbow, and Shoulder options are activated. If the sensors are worn on the upper arm, only the Shoulder option is activated. The joint action options are also activated depending on the sensor locations. For example, if the sensors are worn on the feet, the Adduction/Abduction option is not activated. Select the Positive/Negative option if a movement cannot be classified as Flexion/Extension or Adduction/Abduction. If the Swimming application option was selected, then select either Freestyle, Breaststroke, Backstroke, or Butterfly.

Adjusting the sampling rate

The sampling rate of the Data Monitor routine is automatically set by the Aquanex program according to the speed and type of your computer's CPU. The sampling rate may be adjusted by selecting Rate from the Data Monitor menu bar. There are three absolute adjustments to choose from: Slow, Medium, and Fast. There are also two relative adjustments: 10% Slower and 10% Faster. The absolute adjustments provide a quick way to make large changes in the sampling rate, and the relative adjustments allow more subtle changes. A sampling rate of about 50 samples/sec is recommended for most applications. For a movement of very short duration or if more detail is desired, a sampling rate as high as 100 may be necessary. For a very slow movement a sampling rate of 20 samples/sec may be sufficient.

The sampling rate will also vary depending on the number of sensors that are connected to the CIU. If a maximum of two sensors are connected to the CIU, and the sensors are attached to the same body segment, the sampling rate will be higher than if more than two sensors are connected to the CIU or if sensors are attached to different body segments.

To determine the sampling rate, connect the sensors that are required for data collection to the CIU. From the Data Monitor window, select the Start Collecting Data control. Let data collect until almost an entire screen of data has been collected. Then select the Stop Collecting Data control. Selecting Diagnostics from the menu bar will display the sampling rate. Select Continue to return to the Data/Monitor window. If necessary, adjust the sampling rate with the Rate menu bar command and repeat the diagnostics.

Adjusting the baseline

The vertical scroll bars to the right of the graphs can be used to center the baseline so that there is no force deflection on the graph when no force is being applied to an RSU. It is recommended that the baseline be checked frequently during testing. One click on either scroll bar arrow will move the baseline one unit in that direction. The baseline can be adjusted when the RSU is above or below the surface. If submerged, it is important to ensure that the RSU is stationary and there is no water flow affecting the force readings. Once the baseline is zeroed, click the Start button, then the Stop button to reset. Then, go to Data/Monitor.

Changing the resistive surface

It is important to ensure that the display is consistent with the location of the sensors. The resistive surface that is displayed on the screen is dependent on both the limb (arm or leg) to which the sensor is attached and the segment of the limb (hand/foot, lower arm/leg, upper arm/leg). (Either limb can be selected for sensors that are mounted on the trunk.) If the sensors are mounted on the legs, then the display can be changed by dropping down the Limb submenu and selecting Leg.

If a one channel system (TE1) has been selected from the Model option in the Customize window, two additional options will be visible in the Limb submenu: Left and Right. Since only one RSU is operational, select Left or Right depending on which side of the body the sensor is attached.

After the limb has been selected, the channels can be changed by selecting Channels. As the channels are changed, the display shows the surface on which those RSUs are mounted, providing that the sensors were attached according to the table in the "Computer Interface Unit" section. The scale of forces changes to account for differences in the size of the surfaces of those channels.

Changing the gain

While monitoring, the activity can be performed in the manner in which data is to be collected. It can then be determined if the force curves are clearly visible on the screen. If the force curves fill less than half of the screen, the gain can be increased by selecting Gain/2. This action will cause the subsequently monitored forces to be displayed at twice the height as when operating at the initial gain of 1. The scale of forces on the left-hand side of the screen will change to one-half of the values displayed when the gain equals 1. If that action results in the peaks of the curves going off the screen, the gain can be decreased with Gain/1. Similarly, gain values below 1 can be selected to further decrease the height of the curves.

Changing units

When Metric is selected from the Units menu command, the forces will be displayed in Newtons (N). Calculated values for peak and average forces will be displayed in the Data Analysis, Data Chart, and Data Comparison windows in Newtons. Impulse values will be displayed as the product of Newtons and seconds (N*sec). Selecting US will display the forces in pounds (lbs) and impulse as the product of pounds and seconds (lbs*sec).

Final Adjustments

The baseline, resistive surface (limb, channel), joint, joint action, and gain adjustments can be continued as long as the operator is monitoring. Once data collection has begun, Aquanex collects data with the settings that were last selected during monitoring.

Beginning Data Collection - Start Collecting Data

Data collection is begun by selecting the Start Collecting Data control. Movement of the mouse during data collection can interrupt the process and result in a non-continuous stream of data. The maximum allotted time for data collection in one trial is approximately 5 min with 1-2 RSUs connected or 1.25 min with 3-8 RSUs connected, based on a sampling rate of 50 samples/sec.

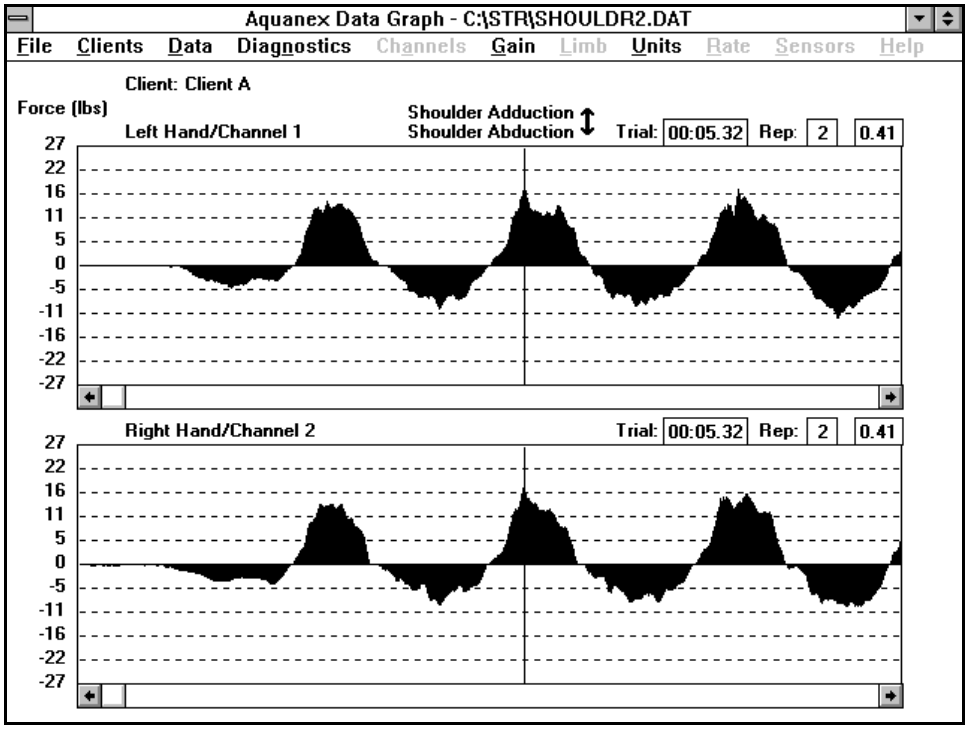
Ending Data Collecting - Stop Collecting Data

The data collection mode continues until Stop Collecting Data is selected, or until the time limit has elapsed. To eliminate the possibility of interrupting the data collection process, it is recommended that data collection be stopped by pressing the Enter key. If a mouse is used to stop collecting data, position the cursor on the Start (Stop) Collecting Data control throughout the trial.

Displaying a Graph - Data/Graph

When data collection has been terminated, the operator may then review the graph of the collected data. Data/Graph may also be used to examine the graph after opening a data file that was previously saved.
The horizontal scroll bars beneath the graphs can be used to scroll through the display. Clicking the scroll arrows moves the graph a small amount and clicking the scroll bar moves the graph by an amount ten times as much as the scroll arrow. The scroll box can be used to move the graph any desired amount. If more than two channels of data were collected, Channels can be used to change channels. The gain and units of the display may also be modified by using the menu bar.

Moving the cursor over the graphs will cause the time to that point in the trial to appear in the Trial data box and the number of the repetition and the time to that point in the repetition to appear in the Rep data boxes. A vertical line can be drawn at any point on the graph by clicking the right mouse button. This

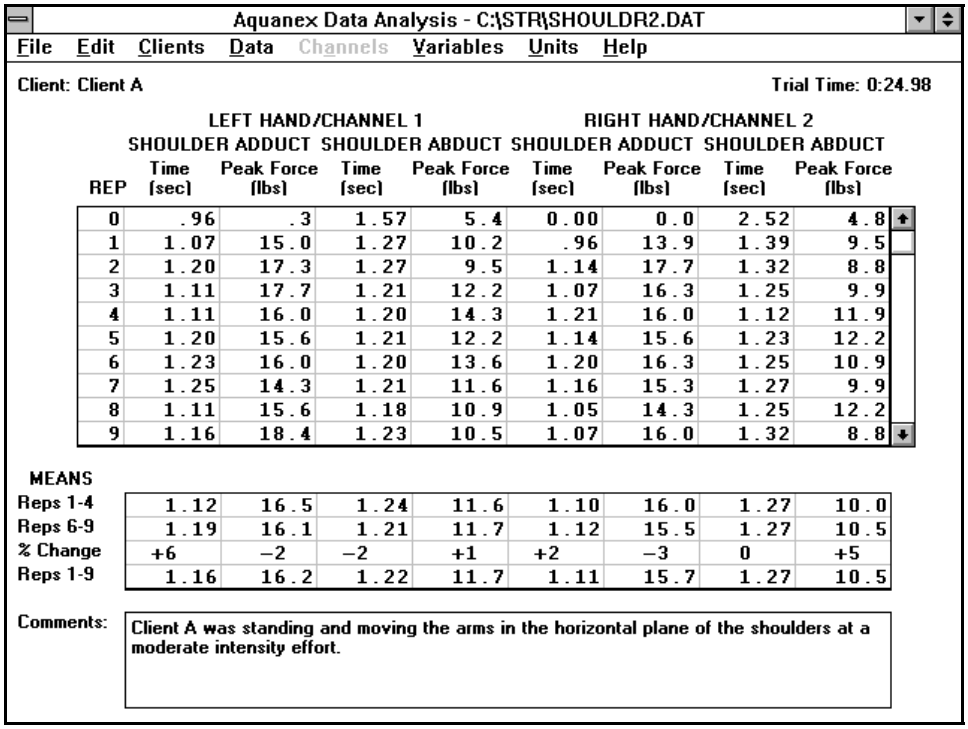


action will also freeze the values in the trial and repetition data boxes for that channel. In the example, the peak value for adduction in repetition 2 occurred at 5.32 sec into the trial and .41 sec into the repetition for both the right and left hands. The vertical lines and the trial and repetition values can be cleared by selecting Data/Graph.

Selecting File/Print will print the graphic image. The best contrast in the printed image will result if the Windows Foreground and Data Foreground colors are set to black and the Windows Background and Data Background colors are set to white (File/Customize, Model/Black on White).

Analyzing Data - Data/Analysis

After data has been collected, the operator may select Data/Analysis from the menu bar. Data/Analysis may be selected either directly after the data collection or after a review of the graph using Data/Graph. Data/Analysis will display a listing of the time duration and peak force for both directions (positive and negative, flexion and extension, or adduction and abduction) of each curve. The maximum number of repetitions that can be analyzed is 100.



If additional channels were active during data collection, select Channels from the menu bar and then select the pair of channels for display (1 & 2, 3 & 4, 5 & 6, or 7 & 8). Variables can be used to choose a display of peak force, average force, or impulse. The Peak Force option displays the greatest instantaneous force value for both directions of each repetition. The Average Force option calculates a mean value for all the instantaneous values for a repetition. The Impulse option sums the instantaneous force values over time to produce a measure of the area under the force-time curve. The Units command allows display in either metric or US units of measure.

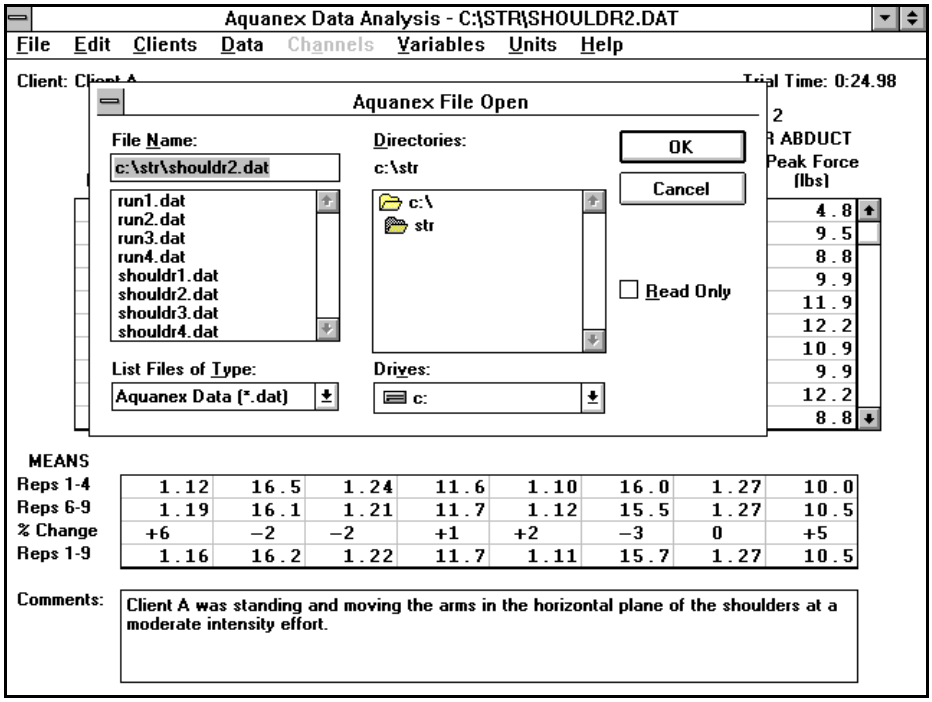
Since the first and last repetitions (Repetition 0 and the last numbered repetition) may not include complete information for those repetitions, they are not included in any calculations of means. For this reason, it is also recommended that neither the first or last repetitions of any trial be used to represent a client's performance.

Averaged values are listed in the MEANS box. The mean values for the first half of the repetitions are listed on the first line of the MEANS box. The mean for the second half of the repetitions are listed on the second line. The difference between the mean for the first and the second halves of the repetitions is expressed as a percentage (% Change) and is listed on the third line. The mean of all repetitions is listed on the fourth line. If there are a different number of repetitions for the displayed channels, the means will be labeled "1st Half" and "2nd Half" instead of with the repetition numbers. There must be a minimum of four repetitions (Reps 0-3) for a mean to be calculated.

Comments can be added to the analysis by pointing the cursor to the Comments box, clicking the left button, and typing. The Edit/Cut Comments will clear the box of all text and copy the comments to the Windows Clipboard. The Edit/Copy Comments will copy the comments to the Windows Clipboard. The Edit/Paste Comments will copy the contents of the Windows Clipboard to the Comments box. If the data is saved (File/Save) as a data file (.dat extension), any comments in the box will be saved with the data. If the data is saved as a summary file (.sum extension), the comments will not be saved with the data. If a report is printed by selecting File/Print, the comments will be printed.

Saving a File - File/Save

After data has been collected, the operator can save it by selecting File/Save from the menu bar. The data may be saved immediately after the data collection has been terminated, after graphing, or after displaying the analysis. From the Data Monitor, Data Analysis, Data Graph, or Data Chart windows, the Aquanex File Save dialog box (similar to the standard Windows File Save dialog box) will prompt the operator for a filename with the .DAT extension. Data files require 12 KB of disk storage space with 1-2 RSUs connected and 48 KB with 3-8 RSUs connected for every minute of data collected at a sampling rate of 50 samples/sec.



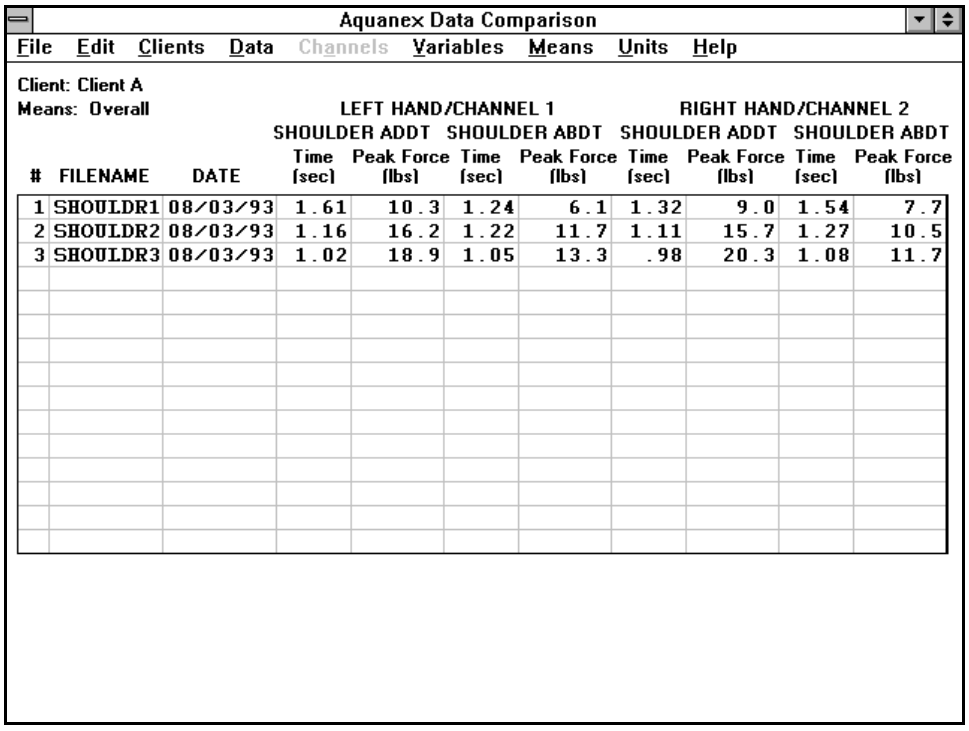
When a data file is saved, a summary file is also saved. The summary file has the same name as the data file, but a .SUM extension. When the data are saved as a summary file, a data file is not automatically saved. Summary files require much less disk space than data files (1 KB with 1-2 RSUs connected and 4 KB with 3-8 RSUs connected for every 10 repetitions). If the operator chooses to save the data as a summary file, the individual data points will not be stored and when the summary file is opened, the Data/Graph option will not replicate the graph.

Opening a File - File/Open

Data that has been previously saved can be opened with File/Open. The Aquanex File Open procedure opens a window similar to the the standard Windows File Open dialog box. Data and summary files can be opened in the Data Analysis and Data Chart windows. Only data files can be opened in the Data Graph window and only summary files can be opened in the Data Comparison window.

Comparing Data - Data/Comparison

The mean values for multiple data files can be compared by selecting Data/Comparison. Files can be added to the Comparison window by using File/Open. Only summary files can be opened in the Data Comparison window. A maximum of 15 files can be open at one time. The client, channel, and limb values must all be identical to the first opened file. A message box will appear if the parameters are not identical. This will help to prevent the comparison of different types of data.



The displayed information may be changed by selecting the Variables, Means, or Units commands from the menu bar. The Variables and Units commands are identical to the commands in the Data Analysis window. The Means command drops down a submenu with 1st Half, 2nd Half, % Change, and Overall commands which produce equivalent values to those in the MEANS box in the Data Analysis window.

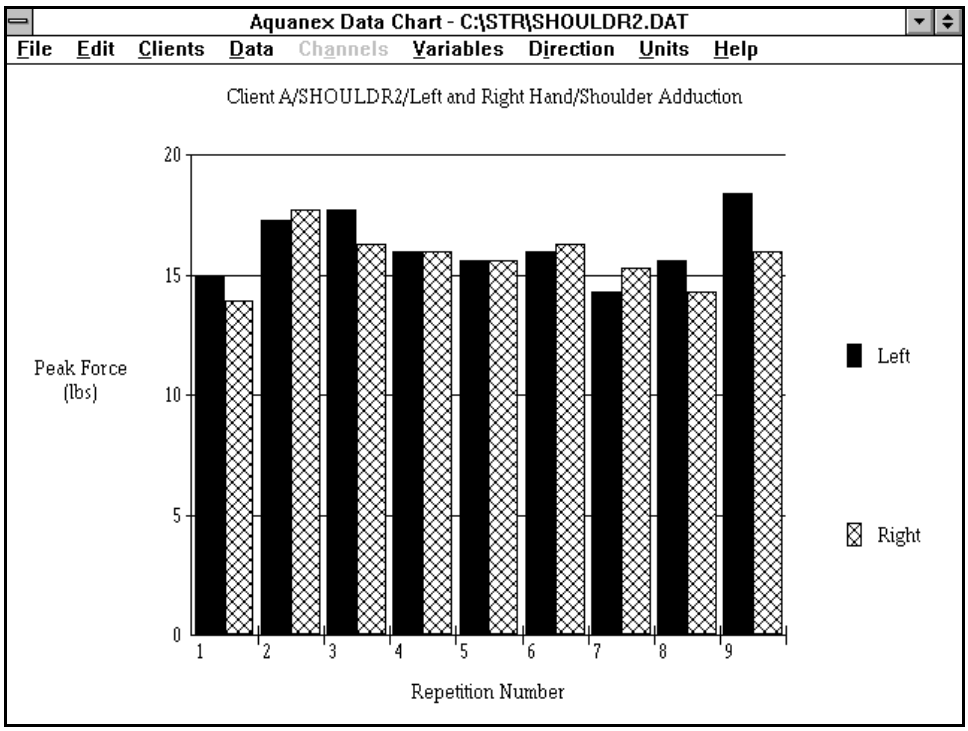
Clicking Edit/Copy will copy all the values in the data box to the Windows Clipboard. To remove a file from the list, first highlight the filename by pointing the cursor and clicking. Then select the Edit/Remove File command from the menu bar. To remove all the listed files, select Edit/Remove All Files.

File/Print will print a comparison report that lists the date of the file and all the currently displayed variables.

Displaying Charts - Data/Chart

Selecting Chart from the Data option on the menu bar will open the Data Chart window and produce a chart. If the Data Chart window is selected from either the Data Graph or Data Analysis windows, the chart will display individual repetition values for the active sum or dat file. If the Data Chart window is opened from the Data Comparison window the chart will display mean values for each file.

The chart shown below was produced by opening the SHOULDR.DAT file in the Data Analysis window and then selecting Data/Chart from the menu bar. Data/Chart will display a maximum of 15 repetitions. If the last numbered repetition in the Data Analysis window is 16, Data/Chart will display repetitions 1-15. If there are more than 16 analyzed repetitions, Data/Chart will display every other repetition. If there are more than 31 repetitions, every third will be displayed, etc.

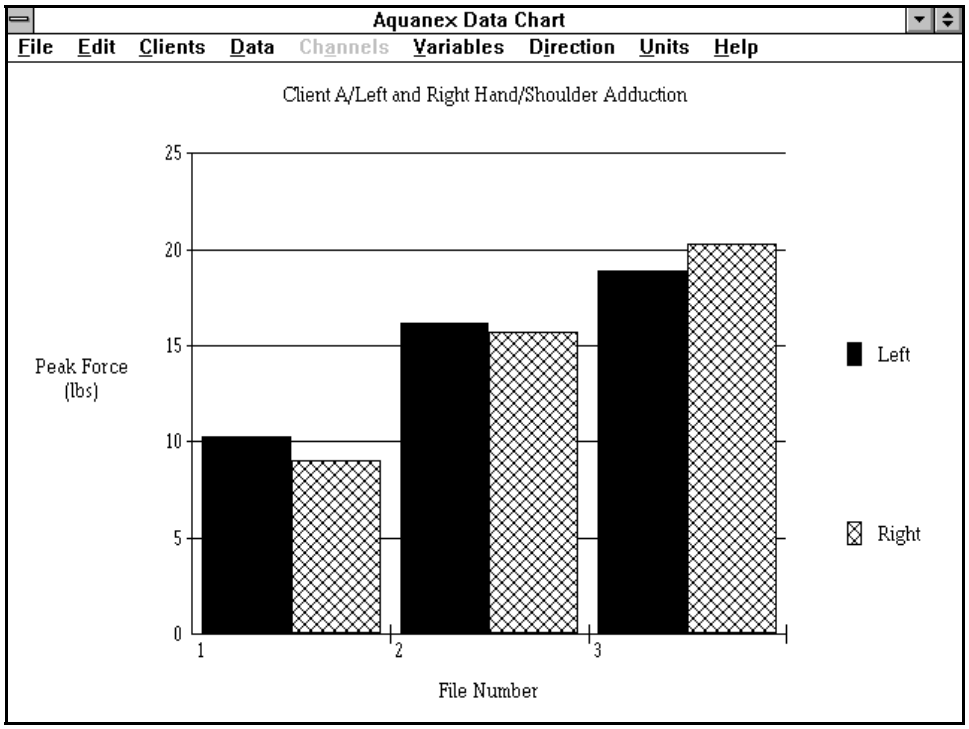


The title line at the top of the chart lists the name of the client (Client A), the filename without the extension (SHOULDR2), the surfaces on which the sensors were attached (Left and Right Hand), and the joint action (Hip Flexion). The sections of the title are separated by slashes (/). If one of the sections is missing, there will be two adjacent slashes.

Data/Chart displays the data for one direction at a time. The data for the opposite direction can be displayed by selecting the Direction option from the menu bar and clicking the desired direction (Positive/Flexion/Adduction or Negative/Extension/Abduction).

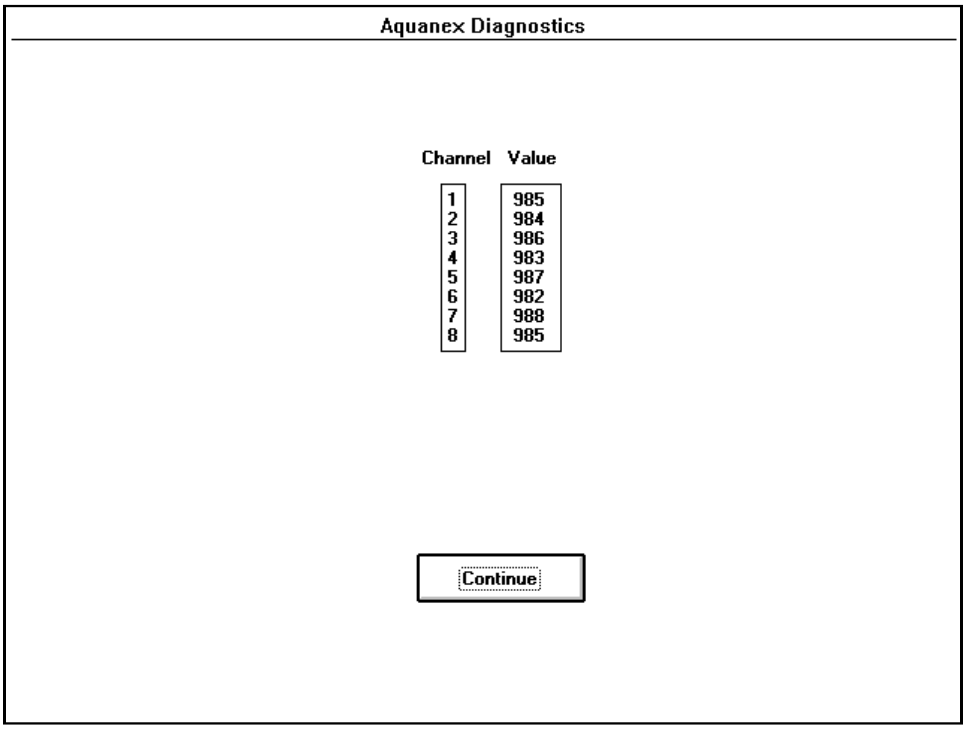
The Variables command can be used to display peak force, average force, impulse, and time. The Channels and Units commands function in the same manner as in the other Data windows. The Edit/Copy command will copy the image to the Windows Clipboard. The File/Print command will print the image.

The chart shown below was produced by opening the SHOULDR1.SUM, SHOULDR2.SUM, and SHOULDR3.SUM files in the Data Comparison window and then selecting Data/Chart from the menu bar. The title at the top of the chart lists the client name, surfaces and joint action. The file numbers listed below the chart correspond to the file numbers listed in the Data Comparison window. The Channels, Variables, Direction, and Units options are available from the menu bar in the same manner as for the repetitions of an individual file. A maximum of 15 files can be simultaneously displayed in the Data Chart window. Printing a copy of both the Data Comparison and Data Chart reports will allow cross-referencing the file numbers with the dates.



Diagnostics - Data/Monitor/Diagnostics

When the Diagnostics menu command is clicked while monitoring data, the Diagnostics window will show the raw data values for all eight channels. If a sensor is not connected, then the channel value should read about 985. If a sensor is connected to a channel and no force is being applied, then the channel value should read about 1190. The values could vary as much as 10 units in either direction.



Diagnostics - Data/Monitor/Start Collecting Data/Stop Collecting Data/Diagnostics

When the Diagnostics command is selected after data has been collected, the Diagnostics window will show the sampling rate. The recommended sampling rate is 50 samples/sec, although rates as low as 20 or as high as 100 may be appropriate for some movements.

Printing Reports and Graphics - File/Print

Selecting the File/Print command from any data window will generate a report or graphic image. Any Windows compatible printer can be used with Aquanex. Either dot matrix or laser printers may be used.

The Data Analysis window prints a report that includes the name of the client, the filename, and the time duration for the trial. The time duration and currently selected variable (peak force, average force, or impulse) will also be printed for both the positive and negative curves of every repetition for both selected channels. Selecting File/Print from the Data Comparison window prints a report that lists the dates and mean performance values for all the open summary files. Selecting File/Print from the Data Graph window prints a copy of the displayed graph. Selecting File/Print from the Data Chart window prints a copy of the displayed chart.

A document on a single trial can be composed from the printouts of the Data Analysis and Data Chart windows. The document can be enhanced with a printout of any particularly informative repetitions from the Data Graph window. A document on multiple trials can be produced from printouts from the Data Comparison and Data Chart windows

Copying Text, Data, and Images to the Windows Clipboard - Edit/Copy Values, Edit/Copy Comment, Edit/Copy Chart, Edit/Copy Client, Edit/Copy All Clients

There are several menu bar options for copying text, data, and images to the Windows Clipboard. From the Clipboard text and images can be pasted into a word processing or desk top publishing document and data values can be transferred into a spreadsheet.

The values listed in the data boxes in the Data Analysis and Data Comparison windows can be copied to the Clipboard with the Edit/Copy Values command. Selecting Edit/Copy Comment copies the text in the comment box in the Data Analysis window to the Clipboard. Selecting Edit/Copy Chart in the Data Chart window copies the chart image to Clipboard. Selecting Edit/Copy Client copies the information for an individual client and Edit/Copy All Clients copies the information for all the clients listed in the Client window to the Clipboard.

Getting Help - Help

Help is provided in a standard Windows Help window by selecting Help.

Terminating Program Execution - File/Exit

File/Exit terminates program execution and returns the operator to Windows.

AQUANEX+VIDEO COMMANDS

An Aquanex+Video system has software with additional commands to handle the video input.

Data/Video

This window displays the video input. Align the camera so that the point on the wall directly opposite the camera is in the center of the field of view and the water surface fills approximately the top 25% of the field of view. A video file can be generated by starting and stopping the video. A 10 sec limit is recommended for capturing video.

Data/Monitor with Video

This window shows both the video and force data. Align the camera so that the point on the wall directly opposite the camera is in the center of the field of view and the water surface fills approximately the top 25% of the field of view. Use the Start/Stop Data Collection button to generate files.

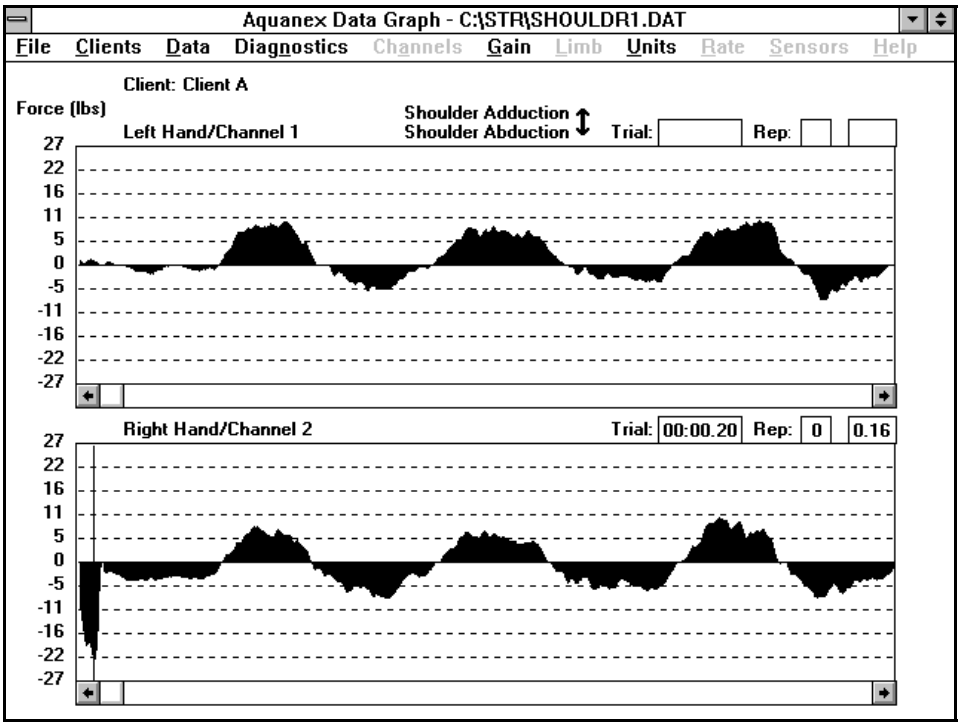
Data/Video Playback and Data/Graph with Video

Use these commands to display video and video with force data, respectively. The multimedia control features from top to bottom are rewind, advance to end, play, pause, single frame back, and single frame advance. The cursors on the graphs are synchronized with the video image.

EXERCISE DATA INTERPRETATION

At the beginning of a testing session it is recommended that the operator have the client exercise at a relatively low intensity (slow speed). The forces should vary about the baseline in the Data Monitor window. If curves in both the positive and negative directions are not distinctly identifiable, first check that the sensors are perpendicular to the direction of motion throughout the range of motion. Next, check the scale of forces. Weaker clients may exert less than 5 lbs (21 N) of force at low intensities. It may be necessary to modify the protocol (e.g. increase the intensity, decrease the area of the resistive surface, or change the joint action).

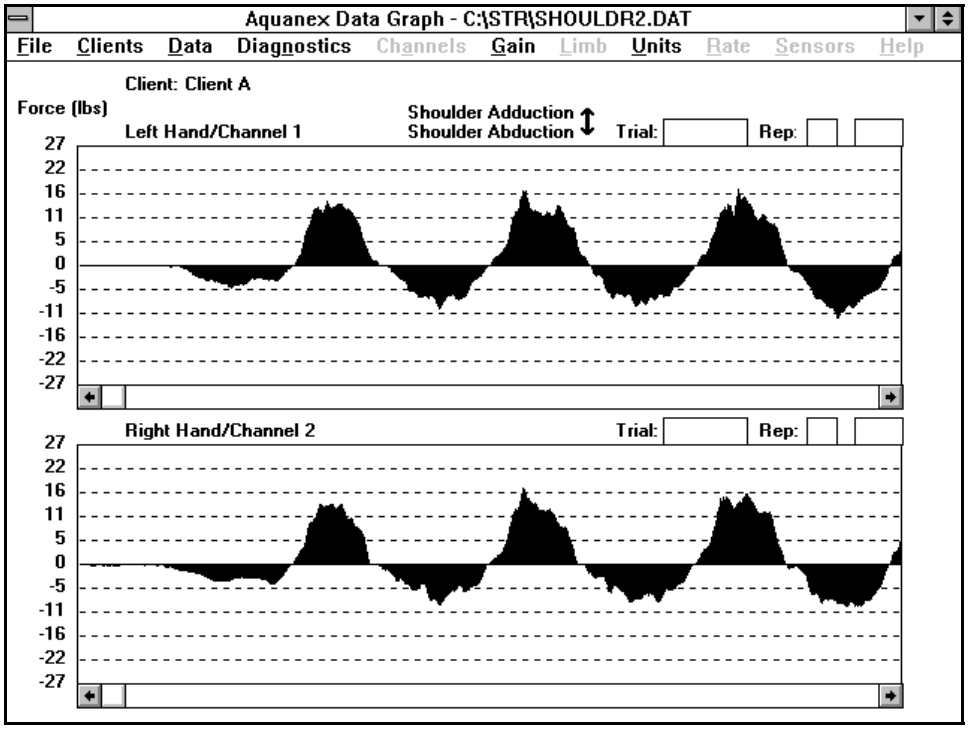
The graphs shown below (SHOULDR1.DAT) are typical for the forces exerted by the hands at a low intensity effort for adduction (positive) and abduction (negative) at the shoulder. The subject was in a standing position with the arms moving in the horizontal plane of the shoulders. The peak forces are about 50 N (12 lbs) for adduction and 30 N (7 lbs) for abduction. Note that for most of the curves the force increases rapidly to a peak and then stays near the peak until the end of the curve. The variation of forces within each repetition will vary with intensity, resistive surface, and from client to client.



The sharp peak for abduction of the right hand (Channel 2) at .20 sec from the beginning of the trial is the result of the positive port momentarily blocked by the client's thumb. Similar peaks can be caused by impact of the sensor on the body or side of the pool. It is best to design the protocol for exercises so that the sensor ports are not blocked at any point in the range of movement and so that the movement does not continue until striking another body part or other physical structure.

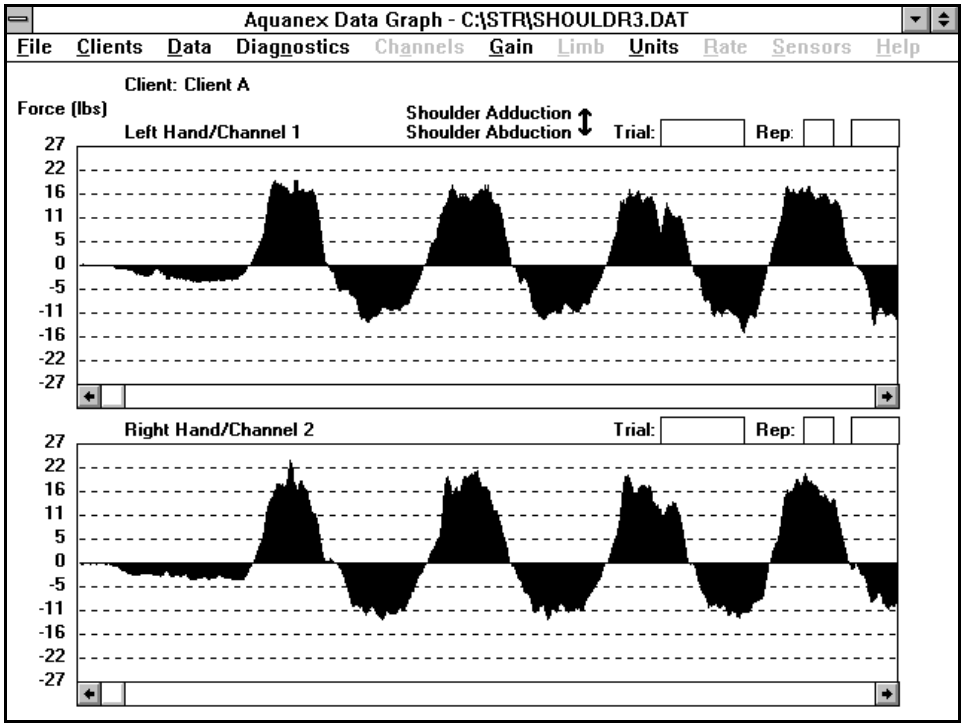
Data collected at low intensity efforts can be analyzed to ensure that the measurements are an accurate reflection of the exercise. The consistency of the time and the peak and average force for the repetitions can indicate the client's level of adherence to the exercise protocol.

The subject was asked to perform the same exercise as in the first trial, but at a moderate intensity. The data are shown in the graphs below (SHOULDR2.DAT). The peak forces increased by about 50% in both directions for both the left (Channel 1) and right (Channel 2) sides. The time duration for each repetition is also noticeably shorter.

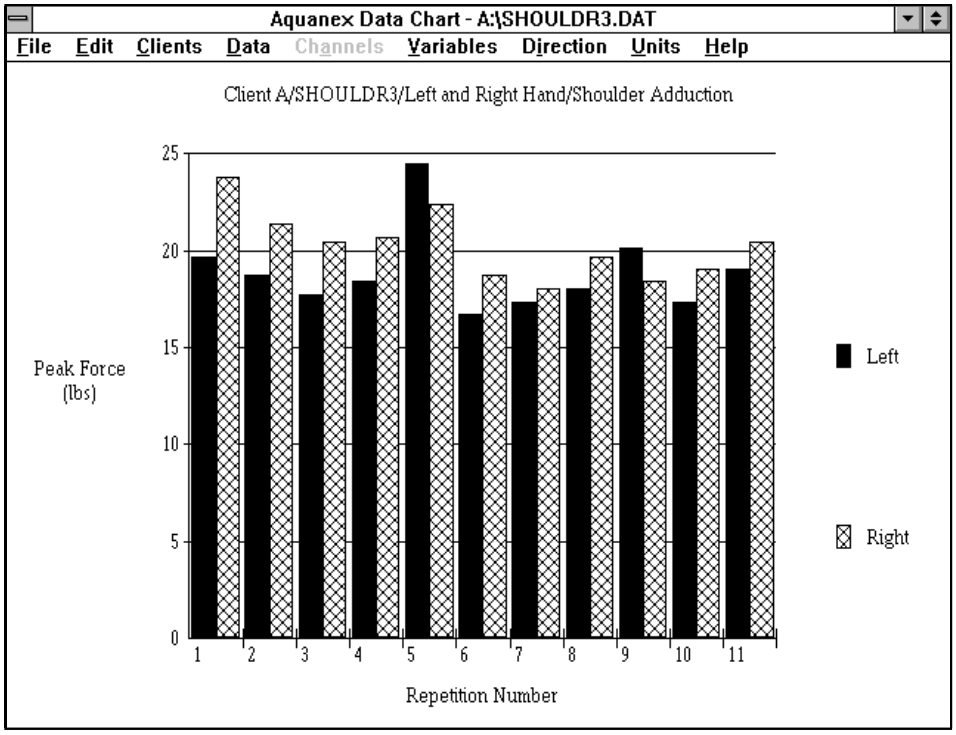


As a client increases the intensity of effort, there are several changes that can typically be seen in the shape of the curves. The force increases more rapidly at the beginning of the curve and decreases more rapidly at the end. The time duration is shorter and the top of the curve will probably be more pointed or even have a fairly sharp peak.

The data for Client A exercising at maximum intensity are shown as SHOULDR3.DAT. A further increase in force and decrease in time duration for each repetition is noticeable. The shape of the curve is also more peaked.



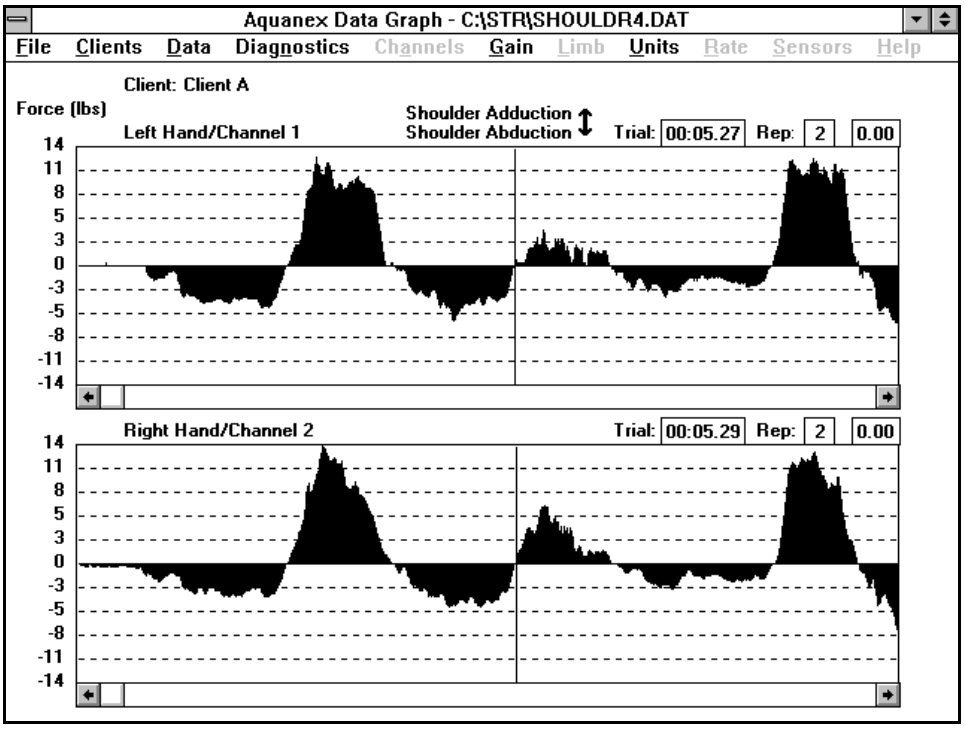
The Data Chart window can sometimes reveal information that may not be readily apparent from either the Data Graph or Data Analysis windows. For example, the chart below shows that the peak force exerted by the right hand on the first five repetitions are all above 20 lbs., but none of the second five repetitions are above 20 lbs. The image can be copied to the Windows Clipboard by clicking Edit/Copy Chart.



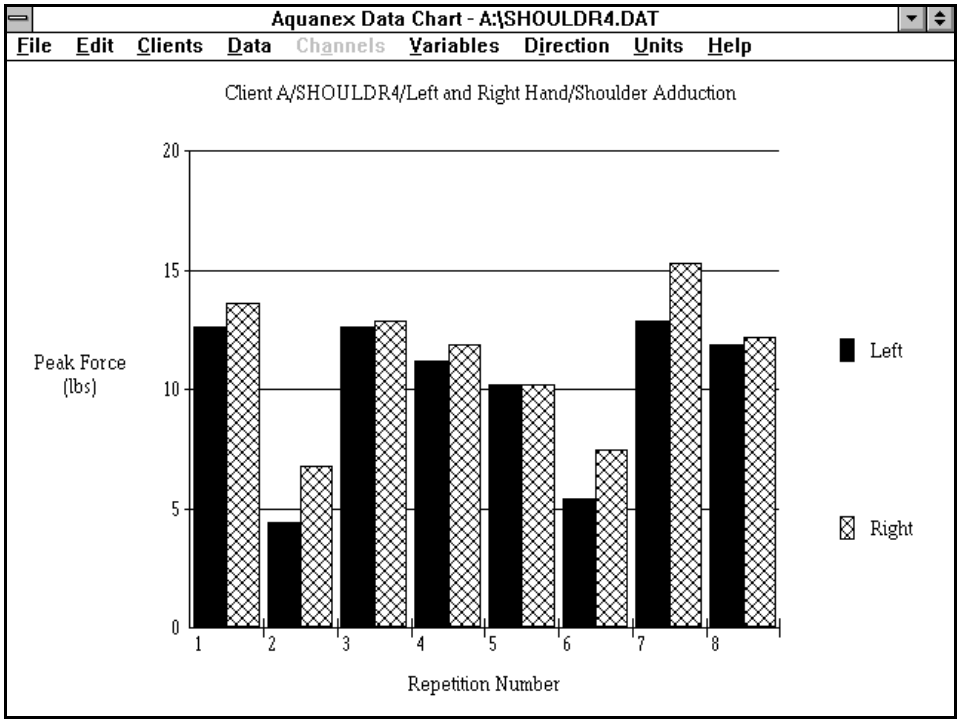
Clients are sometimes tempted to decrease the force necessary to move the resistive surface through the water and, consequently, rotate the resistive surface so that it is not perpendicular to the direction of motion. It is important to specify the manner in which the sensor should be positioned throughout the range of motion.

In the graphs below (SHOULDR4.DAT) Client A has performed adduction and abduction at the shoulder as in the three previous trials, but the forearm was rotated so that the sensor was almost parallel to the direction of motion of the hands during repetition number 2. Vertical lines in the graphs for both channels mark the beginning of repetition number 2. (Note the value of 2 in the Rep data box and the Rep time value of 0.0 sec.)

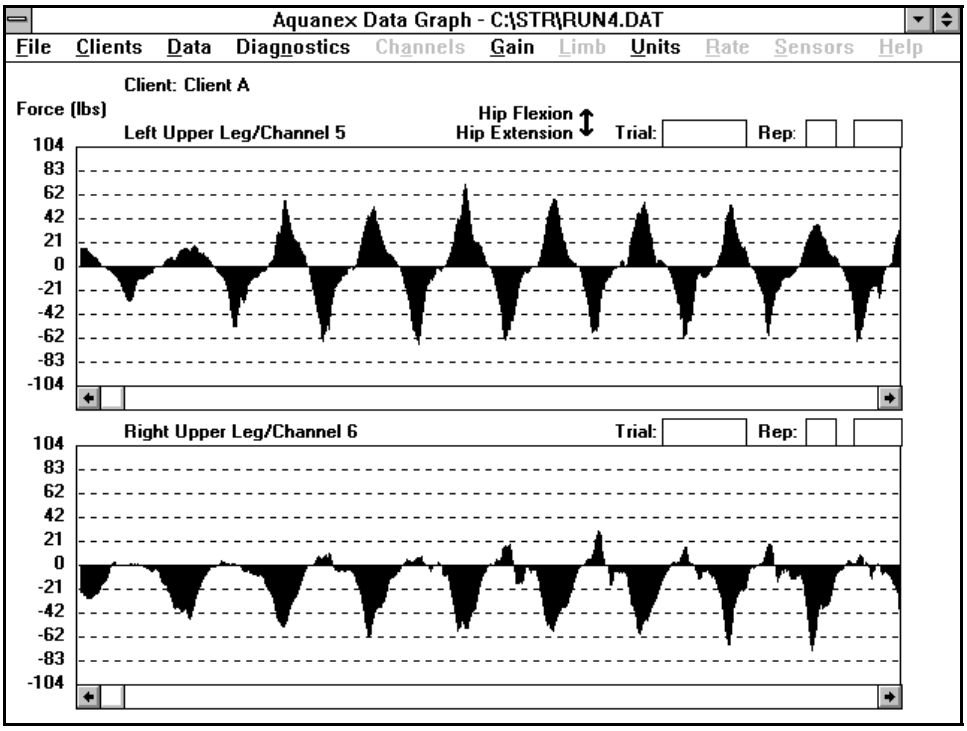
When the forearm was rotated, the resulting peak forces are one-fourth to one-half of the values for the other repetitions. The decrease in the size of the curves and the change in the shape are the two most evident signs of rotation.



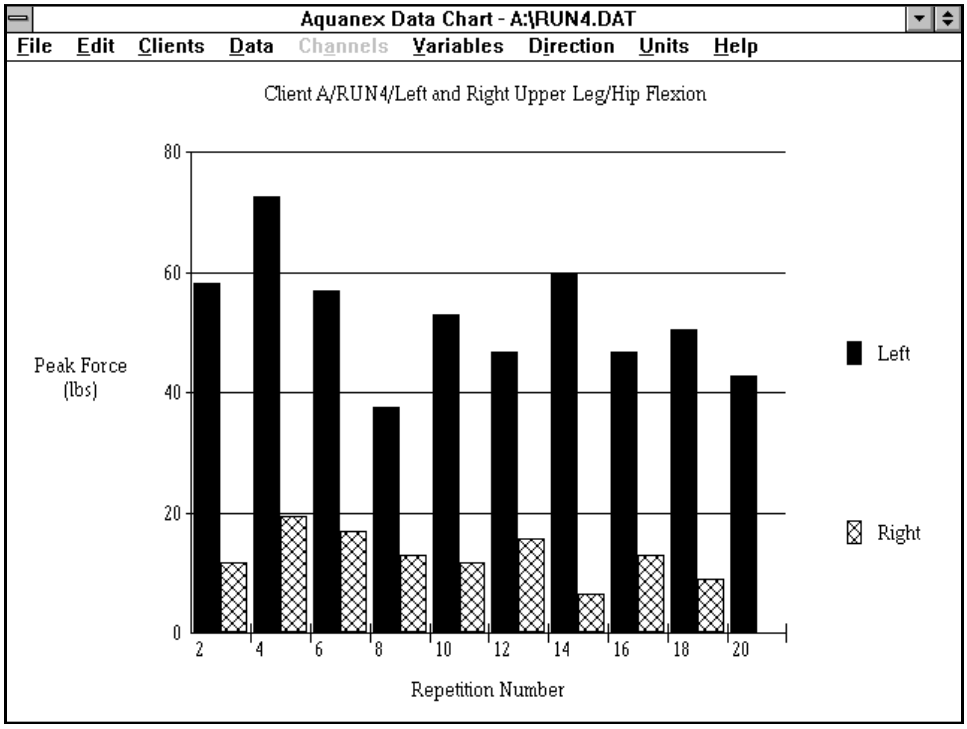
The forearm was again rotated in repetition number 6, as can be seen in the Data Chart window below.



Low force values can also result if the resistive surface moves perpendicular to the direction of motion, but the sensor rotates so that the ports are not perpendicular. The data in the graphs below (RUN4.DAT) were collected while Client A was running in the water with Type B sensors strapped to the upper legs. The sensor on the right leg (Channel 6) was rotated posteriorly (toward the back of the leg). The resulting force values were similar for both legs in the negative direction (hip extension), but the positive values (hip flexion) for the right leg were a fraction of the left leg values.



The bilateral difference in hip flexion can also be clearly seen in the Data Chart window below. All but one repetition for the left leg is above 40 lbs., and all but one repetition for the right leg is below 20 lbs. The Data Chart window can be useful in quantifying the magnitude of bilateral differences and identifying the onset of fatigue.

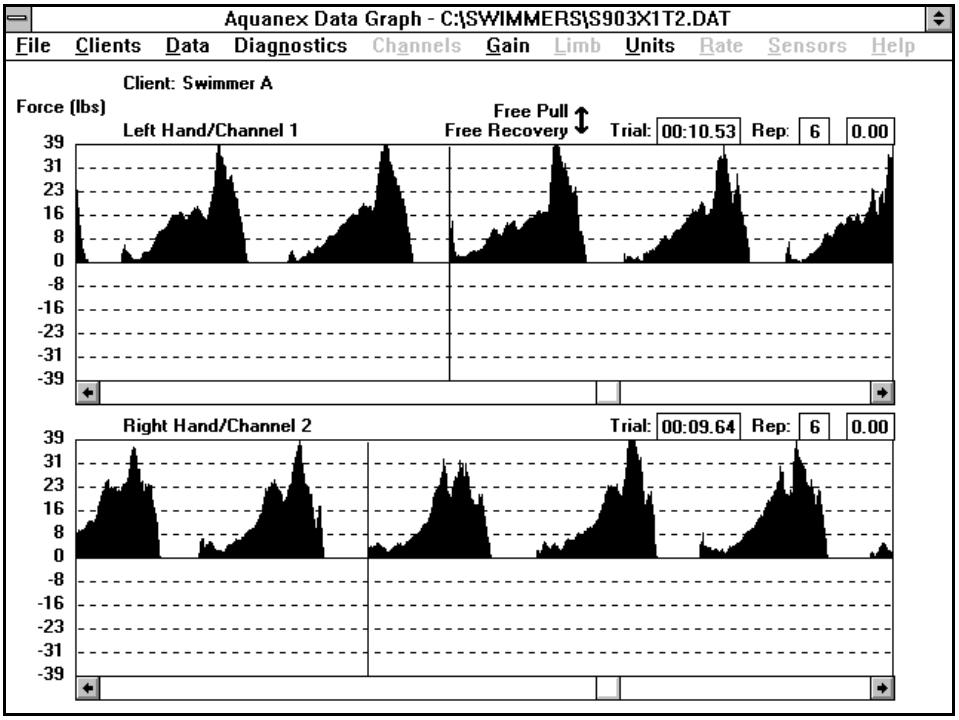


SWIMMING DATA INTERPRETATION

There is a great deal of information about swimming performance that can be determined from Aquanex testing with the most outstanding benefit that it is information that is generally not perceptible to the naked eye. The graphical display of the forces and the analysis of the force and time values can identify potential areas of concern as well as achievement. The swimmer can then target the areas of concern for possible modification and continue to take advantage of the areas of achievement. Retesting can be conducted immediately after a coaching suggestion or after training with a new technique for some period of time to determine improvement. Aquanex quantitative data can also be used to support a coach's qualitative analysis.

Standard Features of Swimming Force Patterns

Although the peak force can be the most tempting feature of a force pattern to focus on initially, the variations in forces within a stroke cycle reveal areas to target for technique modification. Before focusing on a swimmer's unique pattern, there are several standard features of a swimming pull pattern that are fairly easy to identify with Aquanex. The swimmer's hand entry can be identified by the point at which the graph begins to rise above the baseline (o lbs. of force). If the cursor is pointed to the hand entry on the graph, there will be a reading of o.oo in the Rep time box. Note how the vertical line marks the beginning of Rep 6 for both hands in the graph for Swimmer A. The peak force is usually easy to identify as the single greatest force during a pull. However, some swimmers have several peaks that are about as high as the peak. When the hand exits the water, the force drops back down to zero. While the force reads zero, the hand is recovering out of the water.



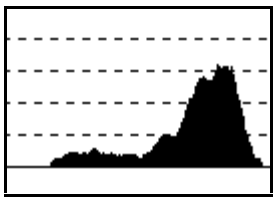
Performance Enhancing Factors

Many elite swimmers exhibit a pattern in which force steadily increases to a peak at about three-fourths of the time from hand entry to exit. The curve shown is from a national caliber swimmer and reflects the increase in force that accompanies the increasing ability to exert force throughout the stroke. There are no major force losses due to change in the hand path, pitch, or speed. Swimming performance will generally be enhanced by steadily increasing force.

Performance Limiting Factors

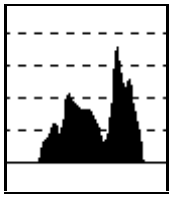
The force pattern of most swimmers will not exactly match the example of the elite swimmer. The differences between a swimmer's pattern and the elite pattern can make it possible to pinpoint factors that limit performance. Almost every swimmer has elements of his/her technique that limit performance. There are distinct force patterns commonly seen in swimmers that are indicative of limiting factors. Three typical limiting factors can be identified from Aquanex graphs. The examples in this section are actual data from competitive swimmers and are characteristic of their performance.

Constant Force



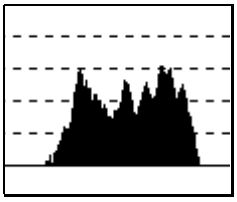
A pull pattern with a constant force for about the first one-half of the pull is shown in the graph. A duration of the pull with a constant force indicates that the swimmer's hand maintains a fairly constant orientation with respect to speed and direction. The rest of the curve is similar to the elite pattern above in that the force increases steadily to a peak. Constant force can be observed at various forces and for various durations. For example, a swimmer with this limiting factor might maintain force at one-half of peak force. Constant force might be maintained for a very short time or for almost the entire duration of the pull. Wasted motion is generally associated with a constant force phase.

Loss of Force



A pull pattern with a typical loss of force might begin similarly to the elite pattern shown above, but the force noticeably decreases prior to the peak. Loss of force can result from a change of direction of the hand path and/or pitch; or a decrease in hand speed; or a combination of change of direction and decrease in speed. Variations of this pattern could have multiple noticeable decreases in force prior to the peak. These decreases can range from less than one-tenth to over one-half of the peak force value.

Inconsistent Force



A pull pattern with an inconsistent force is characterized by multiple increases and decreases in force beginning with an initial increase in force shortly after hand entry that may approach or even achieve peak force. A swimmer with this limiting factor has adjusted his/her hand orientation on entry so that he/she is unable to steadily increase force throughout the pull. A contributing factor could be that the swimmer is unaware about the importance of continuing to increase force throughout the pull. In variations of an inconsistent force pattern, the force might

initially rise to about one-half the value of the peak and increase and decrease several times before hand exit.

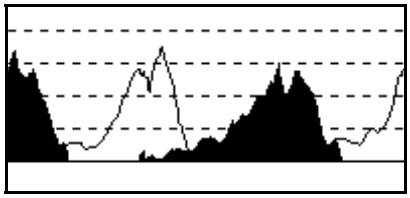
Combinations of Limiting Factors

The examples were selected because they illustrate one limiting factor as a predominant feature of the pull pattern. A pull pattern can, and very often will, have more than one type of limiting factor. For example, a swimmer's pull might have a fairly constant force at the beginning of the pull and have a loss of force prior to the peak. Or, a pull pattern may resemble that of an elite swimmer for the first half, but be inconsistent for the second half. The force curves of Swimmer A generally increase steadily and quickly to a peak similar to the elite pattern. However, there are elements of all three limiting factors in the pattern. There is usually a force loss of at least 5 lbs. and sometimes over 10 lbs. just prior to the peak. The loss is not as great a proportion of the total curve as the loss of force example. The swimmer's right hand pattern maintains a fairly constant force for about the first one-fourth of the pull, somewhat similar to the constant force example. The left hand occasionally has a force spike on entry. While the overall pull pattern does not resemble the inconsistent force example, the entry spike indicates an orientation adjustment of the hand that limits performance similar to the example.

Variability of Limiting Factors

If a swimmer uses the same technique with the same intensity of effort, a force pattern will be replicated. The major limiting factors of a swimmer will generally be noticeable in every stroke and even on trials conducted on different days. However, not every swimmer will exert the same effort with the same technique on every trial or even on consecutive strokes. Therefore, there can be variability in the limiting factors that are exhibited by the same swimmer. For example, simply turning the head to breathe can influence the hand movement and alter the force pattern. While a swimmer's force pattern might be free of limiting factors when not breathing, there might be a considerable force loss on a breathing stroke. A fatigued swimmer's force pattern may reveal limiting factors and lower force values than when the swimmer is rested. Force patterns can also vary between arms of the same swimmer, revealing different limiting factors for each arm. Bilateral differences can be attributed to handedness, breathing, breathing side, body position, and effort.

Bilateral Timing of Force Patterns



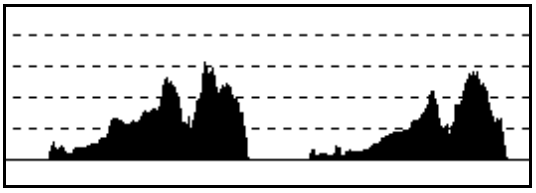
By using the overlap features of the Data Graph window, the timing of the left and right hands can be examined. The Overlap Opposite Channel displays the forces for the other hand in outline. This feature makes it possible to see if each hand begins exerting force before the opposite side finishes pulling, so that there is a continuous application of force. If the force of one side drops near the baseline before the beginning of the pull can be seen for the other channel, it may be advantageous for the swimmer to increase the speed of recovery so that each recovering hand begins to exert force before the opposite hand has finished the pull.

A timing analysis is useful in determining the net effect of changes that a swimmer makes after instruction. For example, a swimmer that exhibited a lack of overlap in forces for the left and right hands was given the suggestion to increase the speed of recovery in the hope that each hand would then begin to pull before the opposite hand finished. When retested, it was determined that the swimmer had decreased the recovery time, but had also decreased the pull time with no net effect on improving the overlap.

Changes in Force Patterns and Force Values

Aquanex has the sensitivity to detect subtle changes in the pattern of application of force and the in the resulting magnitude of the quantitative variables. Noticeable changes in force can be detected with changes in the intensity of effort, with the onset of fatigue, and with instruction.

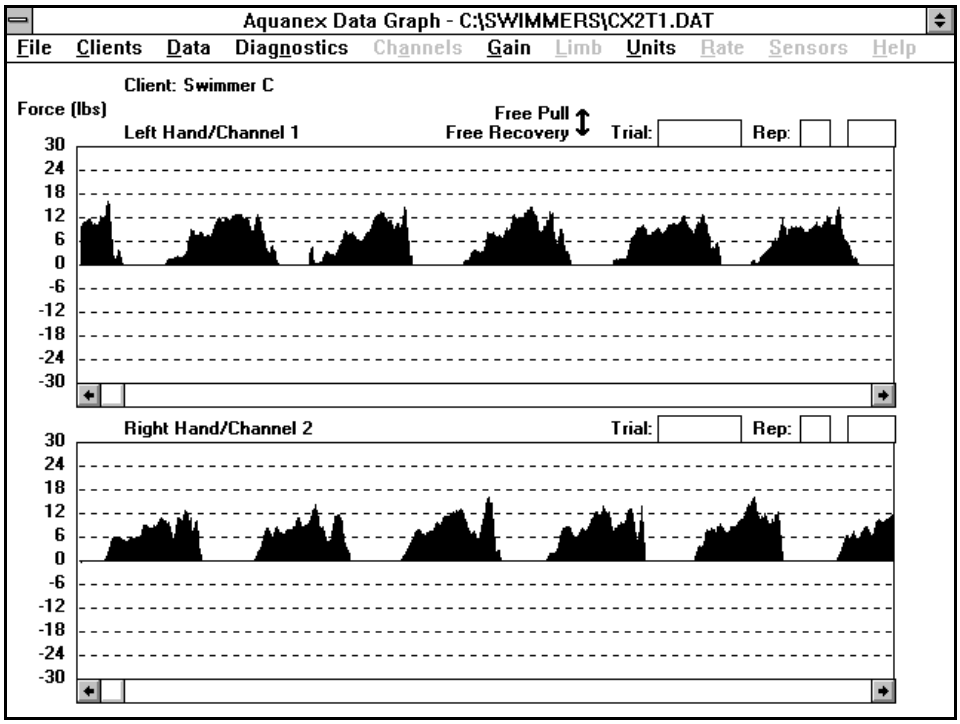
Changes with Intensity of Effort



Different limiting factors may be noticeable at different intensities. For example, at a low intensity (slower speed) a swimmer's pull might look similar to a curve with the constant force limitation. The duration of this limitation will probably decrease or even be eliminated at faster speeds. It is also possible for a different limiting factor to develop. It is also possible for a pull pattern to be more effective at faster speeds. Note the force loss for the left hand of Swimmer A, when swimming at less than maximum effort. Compare this graph with the previous graph for Swimmer A swimming at maximum effort.

Changes with Instruction

Swimmer C was tested swimming freestyle and the force curves are shown below (CX2T1.DAT). Many of the curves are similar to the inconsistent force example in which the force varies between a value as high as the peak and as low as one-half of the peak for the majority of the pull. The peak force for both hands is usually just over 12 lbs. and never over 18 lbs. After this trial, the swimmer was given a suggestion by her coach to increase force throughout the entire pull, and was immediately retested.



In the second trial (CX2T2.DAT) most of the peaks are over 18 lbs. A few of the curves show a more clearly defined peak just prior to hand exit. Although many of the curves still show inconsistent force patterns, this is to be expected after only one coaching tip and no opportunity to practice. The fact that there is any noticeable change is encouraging.

Summary

The graphs of swimming pull patterns can be used to identify the characteristic limiting factors of a swimmer's technique. Changes in limiting factors due to intensity of effort, fatigue, and instruction can be tracked. Retesting can be conducted to determine the effect of technique modifications.

SUMMARY OF OPERATING PROCEDURES

The operating procedures are divided into sections on setup, activating software, data collection, and report printing.

Summary of Setup

1. Check the safety of the power supply (see CAUTION FOR USE on page 2).
2. Connect the computer and the CIU with the CIU cable.
3. Connect the RSUs to the corresponding sockets on the CIU.

Summary of Activating Software Program

1. Turn on the computer.
2. Activate Windows.
3. Activate the AQUANEX program.

Summary of Data Collection

1. Select Clients from the menu bar.
2. Choose the name of the client to be tested or choose Edit/Add Client and add the client's name, height, and weight.
3. Select Data/Monitor.
4. Check the sensor type and series setting by clicking Sensors.
5. Select the channels of interest from Channels.
4. Select the joint action from the Sensors submenu.
6. Adjust the baseline with the vertical scroll bars.
7. Adjust the gain with Gain, if necessary.
8. Begin data collection by clicking Start Data Collection.
9. End data collection by clicking Stop Data Collection.
10. Review the graph of the collected data with Data/Graph.
11. Review the analysis of the collected data with Data/Analysis.
11. Review trends in the collected data with Data/Chart.
12. Save the data with File/Save.

Summary of Printing Commands

1. Select Clients from the menu bar and select the client.
2. Access a previously saved trial by selecting File/Open.
3. Review the data with Data/Analysis.
4. Print a report of the file with File/Print.
5. Review the graph with Data/Graph.
6. Print a copy of the graph with File/Print.
7. Review the chart with Data/Chart.
8. Print a copy of the chart with File/Print.

SUMMARY OF CONTROL OPTIONS

The control options are: menu bar commands, command buttons, and scroll bar commands.

Summary of Menu Bar Commands

The following are menu selections in the Clients window and all Data windows:
File - drops down the File submenu with the options: Open, Save, Print, Customize, Exit
Data - drops down the Data submenu with the options: Monitor, Graph, Analysis, Comparison, Chart
Units - drops down the units submenu with the options: Metric, US
Help - displays the Help window

The following are File submenu selections:
Open - displays the File Open dialog box
Save - displays the File Save dialog box
Print - prints a report or graphic image
Customize - displays the Customize window
Exit - exits from the Aquanex Program and returns to Windows

The following are Data submenu selections:
Monitor - displays the Data Monitor window
Graph - displays the Data Graph window
Analysis - displays the Data Analysis window
Comparison - displays the Data Comparison window
Chart - displays the Data Chart window

The following are menu selections in the Customize window:
Model - drops down the Model submenu with the options: D1 or DE8, DP8, DS1, T1 or TE1, TP1
Color - drops down the Color submenu with the options: Window Foreground, Window Background, Data Foreground, Data Background, Black on White

The following are menu selections in all Data windows:
Clients - displays the Clients window
Channels - drops down the Channels submenu with the options: 1 & 2, 3 & 4, 5 & 6, 7 & 8

The following is a menu selection in the Data Monitor and Data Graph windows:
Gain - drops down the Gain submenu with the options: .10, .25, .50, 1, 2, 4

The following are menu selections in the Data Monitor window:
Diagnostics (during Monitoring) - displays the Diagnostics window with data values for all eight channels
Diagnostics (after collecting data) - displays the Diagnostics window with the sampling rate
Limb - drops down the Limb submenu with the options: Arm, Leg, Left, Right (the Left and Right options are only visible for one channel systems).
Rate - drops down the Rate submenu with the options: Slow, Medium, Fast, 10% Slower, 10% Faster
Sensors - drops down the Sensors submenu with the options: Type A or B, Type C or D, Series 25, Series 40, Series 80, Positive/Negative, Flexion/Extension, Adduction/Abduction, Wrist, Elbow, Shoulder, Hip, Knee, Ankle

The following is a menu selection in the Data Analysis, Data Chart, and Data Comparison windows:
Variables - drops down the Variables submenu with the options: Peak Force, Average Force, Impulse
The following is a menu selection in the Data Comparison window:
Means - drops down the means submenu with the options: 1st Half, 2nd Half, %Change, Overall

The following are menu selections in the Data Chart window:
Direction - drops down the direction submenu with the options: Positive/Flexion/Adduction, Negative/Extension/Abduction

The following is an Edit submenu selection in the Data Chart window:
Copy Chart - copies the chart to the Windows Clipboard

The following are Edit submenu selections in the Clients window:
Copy Client - copies the data for the highlighted client to the Windows Clipboard
Copy All Clients - copies the data for all clients to the Windows Clipboard
Add Client - opens the Add Client window for entry of a new client
Edit Client - opens the Edit Client window for editing client data
Delete Client - deletes the selected client from the Client window

The following are Edit submenu selections in the Data Analysis and Data Comparison windows:
Copy Values - copies the values from the data box to the Windows Clipboard

The following are Edit submenu selections in the Data Comparison window:
Remove File - removes the highlighted file from the list
Remove All Files - removes all files from the list

The following are Edit submenu selections in the Data Analysis window:
Cut Comment - cuts the comment from the comment data box and copies it to the Windows Clipboard
Copy Comment - copies the comment from the comment data box to the Windows Clipboard
Paste Comment - pastes the contents of the Windows Clipboard into the comment data box

Summary of Command Buttons

Continue - resumes program execution
OK - resumes program execution
Cancel - terminates execution of active window
Start Collecting Data - begins data collection
Stop Collecting Data - terminates data collection

Summary of Scroll Bar Commands

Scroll Arrow - scrolls the display by a small amount
Scroll Bar - scrolls the display by an amount ten times as much as the Scroll Arrow
Scroll Box - can be used to increment the display by an amount selected by the operator

TROUBLESHOOTING

In the event of a problem, review of the following procedures may prevent the need to call for assistance.

Problem

Computer does not operate, baseline is erratic, or forces are far below expected values.

Possible Solution

Check that all components are properly connected and have an adequate power supply.

Problem

Aquanex software terminates execution unexpectedly.

Possible Solution

Check that all computer hardware is 100% IBM compatible and that all software settings are 100% Microsoft Windows compatible.

Problem

Aquanex software begins to run but displays the Aquanex Error "File Not Found."

Possible Solution

Check that the CLIENT.LST, COMPANY.LST, and STRLOGO.BMP files are located in the same folder in which Aquanex was installed.

Problem

Baseline is not visible in the Data Monitor window.

Possible Solution

Check that the Data Monitor window is set to the proper channels.
Check that the RSUs are plugged into the proper channel socket.
Check that the Data Output from the CIU is connected to the same USB port used during installation.
Run the diagnostics (Data/Monitor/Diagnostics) and record the values for all eight channels.
Exit Aquanex. Disconnect CIU. Reconnect CIU. Run Aquanex.
Exit Aquanex. Disconnect CIU. Reboot computer. Reconnect CIU. Run Aquanex.

Problem

Baseline is erratic and cannot be zeroed.

Possible Solution

Check that the RSU is stationary and repeat the baseline adjustment.
Remove the RSU from the water and repeat the baseline adjustment.
If the computer has a Pentium processor, click the Pentium option under the Computer menu bar option in the Custom window.

Problem

Forces are uncharacteristically higher in one direction and lower in the opposite direction.

Possible Solutions

Hold the RSU stationary and check that the baseline is on zero.
Check that the ports of the sensor are positioned perpendicular to the direction of movement throughout the range of motion.

Problem

Baseline is visible in the Data Monitor window for a channel with no RSU connected.

Possible Solution

Check that the sensor type is properly identified in the Sensors submenu.
Run the Diagnostics.

Problem

Mouse does not operate with Model DP2, DP8, or DS1 interface.

Possible Solution

Wait until the computer has booted into Windows before connecting the interface power cable.

Problem

There is no video image.

Possible Solution

Disable the web camera – Control Panel/Device Manager/Imaging Devices.
Check that the video input cable is completely seated in the camera cable socket.
Check that there is adequate battery power to the camera. (9 to 12 v)
Check that the Video Output from the CIU is connected to the same USB port used during installation.
Run Amcap.exe from the Video Drivers/Driver directory on the CD. Select Options/Video Capture Filter . . . /Image Tab/Composite Video or select Options/Video Crossbar/Video Composite.
Open Device Manager, right click on each DVC100 entry and Update Drivers.
Reinstall Video Drivers.

Problem

Video is not synchronized with force data.

Possible Solution

Check the Model setting in the Customize window.
Run Disk Cleanup.
Run Disk Defragmenter.
Delete files to make more room on the hard drive.
Decrease the time/distance for data capture. (A 10 m trial is recommended.)
Increase the computer's RAM.
Capture at least two trials so that the computer can allocate RAM.

Problem

Windows terminates when opening Data/Video or Data/Monitor with Video window.

Possible Solution

Connect the Aquanex video output to a different USB port and then restart the Aquanex software.

Problem

There is a video image in the Data/Video or Data/Monitor with Video window, but no video is captured.

Possible Solution

Check that the Properties/Attributes of the capture.avi file in the C:\ directory are not Read-only.
Right click on Aquanex.exe and set the file to Run as . . . Administrator.
If using Windows Vista, disable user access control (uac) and grant full control access to the C:\ directory to your account.

Problem

The Aquanex software does not load because of a "System files are out of date" error.

Possible Solution

Update Windows files – Control Panel/Automatic Update.

Problem

The video drivers setup.exe will not run with Windows XP with Service Pack 3 or Windows Vista with Service Pack 1.

Possible Solution

Right click on setup.exe and go to Properties/Compatibility/Compatibility Mode and set Run this program in compatibility mode for Windows XP with Service Pack 2.

Problem

Aquanex.exe generates an error (dd =2) on startup under Windows Vista.

Possible Solution

Right click on Aquanex.exe and select Properties, Compatibility, Privilege Level, Run as Administrator.

Problem

Aquanex.exe generates an error under Windows Vista.

Possible Solution

Open Control Panel/System/Hardware/Device Manager and in the HytekUSBDAQ category, right click on iUSBDAQ, select Property/Power Management and uncheck the "Allow the computer to turn off this device to save power."

Problem

Model 17 (TU2V) generates an error when opening the Data/Monitor window.

Possible Solution

Open Control Panel/System/Hardware/Device Manager. Click the + sign on Ports (COM & LPT) and note the com port designation for CP210x. Enter the COM number in the Aquanex software in the Customize window.

Problem

Sensor value is constant at 1000 in the Diagnostics window.

Possible Solution

Exit Aquanex. Reinstall Data Drivers. Restart Aquanex.

Exit Aquanex. Disable digital signature. Reinstall Data Drivers. Restart Aquanex.

Problem

The display in the Data Monitor or Data Monitor with Video is distorted so the video overlaps the force data and the force graphs are elongated.

Possible Solution

Check that the text size is set to 100% in Device Manager/Display.

Problem

The video display in the Data Video or Data Monitor with Video window is green.

Possible Solution

Run Amcap.exe from the Video Drivers/Driver folder on the CD. Select Dazzle under the Devices menu bar option. Select Options/Video Capture Filter . . . /Image Tab/Composite Video or select Options/Video Crossbar/Video Composite.

Problem

After a Windows update, the data and video drivers are no longer installed.

Possible Solution

Disable digital signature. Reinstall Data Drivers. Restart Aquanex.

If the above solutions do not solve the problem, check with STR to get the most recent Aquanex.exe file.

WORKING WITH WINDOWS

The windows environment may be used to transfer an image from the Aquanex program to a word-processing or desk top publishing program. For example, any Aquanex window can be copied to the Windows Clipboard by pressing the Print Screen key. The Aquanex screen can then be cleared by minimizing the window (clicking the minimize button in the upper right hand corner). Windows Write (or another Windows program that has the capability of pasting images from the Windows Clipboard) can be opened from the Accessories window in the Program Manager. The Aquanex window can be displayed in the Write window by clicking the Edit/Paste menu bar command. After the Write session has been concluded, Aquanex can be reopened by double clicking the Aquanex icon.

The Windows Clipboard can also be used to transfer Aquanex images using Aquanex copy commands. The data for one client can be copied to the Clipboard using the Edit/Copy Client command in the Client window. The data for all clients can be copied using the Edit/Copy All Clients command. The graphic image in the Chart window can be copied to the Clipboard with the Edit/Copy Chart command. The comments in the Analysis window can be copied with the Edit/Copy Comments command. Client information from other Windows programs (demographics, billing, etc.) can also be copied to the Clipboard. A document can be composed by pasting the Clipboard images and adding any necessary explanatory text.

ERROR HANDLING

The system is programmed to report errors. In the event of an error, the operator is notified and given information about the error. Record any error messages and error numbers.

SAMPLE DATA

Files with data that were previously collected have been provided on the Aquanex diskette. Files with the "DAT" extension (e.g. SHOULDR1.DAT) are data files and files with the "SUM" extension are summary files. The sample files are not installed on your computer by the setup program. They can either by copied onto your hard drive or opened directly from the diskette.

FOR TECHNICAL ASSISTANCE

For technical assistance on the use and function of AQUANEX, please contact:

Swimming Technology Research, Inc.
3743 Chellowe Rd.
Richmond, VA 23225
850-385-9803
swimmingtechnology.com
info@swimmingtechnology.com

If you are experiencing a problem with software, before calling for assistance please record the complete version number from the title screen (e.g. V1.0 C9206). If you are having a hardware problem, please have the serial numbers for the components from the packing list available.

SYSTEM SPECIFICATIONS

Minimum Computer System Requirements
Models DP2, DS2, DP8 - Pentium CPU with Windows 95
Models DU2, DU2V, TU2, TU2V - Pentium 4 with Windows XP with Service Pack 2.
Model DU2V (19 or higher) - Dual core processor with Windows 7 64-bit

Power Requirements
All interfaces and direct cable sensors are powered by the computer.
Telemetry sensors are powered by their own battery.

System Limitations
Maximum sampling rate using the minimum computer system requirements is 100 samples/sec.
Maximum transmission distance for RSU/T is 25 m.
Maximum number of repetitions per trial is 100.
Maximum number of clients in database is 500.
Maximum allotted time for data collection in one trial is 5 min at 50 samples/sec.

Approximate File Sizes
Data files (.dat extension) require 12 KB for every 1 min. of data collected at 50 samples/sec.
Summary files (.sum extension) require 1 KB for every 10 repetitions.
Video files (.avi extension) require 5 MB per sec.

Standard Sensor Features
Model D sensors weigh 8 oz. and connect to the interface with a 50 ft. cable.
Model T sensors weigh 8 oz. and have a 6 ft. cable between the sensor element and the transmitter case. The transmitter case is a plexiglass cylinder with a diameter of 2.5 in and a length of 4 in.

Sensor Dimensions/Installation Requirements
Type A sensors are 1.25 in. x .75 in. x 1 in.
Type B sensors are 2 in. x 1.5 in. x 1 in. and have a 24 in. x .75 in. rubber strap with a bayonet clip.
Type C sensors require a minimum space of 1.25 in. x .75 in. x .5 in. and are custom installed by STR.
Type D sensors are 1.25 in. x .75 in. x 1 in. and can be installed on any flat surface that has a maximum thickness of .75 in. Type D sensors have a .75 in. long mounting screw with wingnut and require two mounting holes with diameters of 3/16 in. and 5/16 in. that are centered .75 in. apart.

Sensor Performance (maximum values)
Sensors have an accuracy of .2%.
Series 25 sensors have a sensitivity of .4 lb./unit and a range of 1,000 lbs. positive to 95 lbs. negative.
Series 40 sensors have a sensitivity of .25 lb./unit and a range of 1,000 lbs positive to 85 lbs. negative.
Series 80 sensors have a sensitivity of .125 lb./unit, and a range of 500 lbs positive to 75 lbs. negative.

CLINICAL AND RESEARCH REFERENCE LIST

Havriluk, R. (2010). Analyzing hand force in swimming: Characteristics of Olympic sprinters. *American Swimming Magazine*, in press.

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CLINICAL AND RESEARCH DATA

The data listed below were collected using Aquanex in clinical and research settings. In all cases the subjects or patients were performing horizontal adduction and abduction at the shoulder while standing in the water with the arms parallel to the surface of the water. The column labelled **Ref** refers to the reference for the testing, where Ref 1 is unpublished data collected by STR and Ref 2 is unpublished data collected by Prins Aquatherapy; **Sample** indicates whether the sample consisted of research subjects or patients; **Size** indicates the sample size; **Surface** refers to the equipment or body surface used as the resistive surface; **RSU** is the type of RSU mounted on the resistive surface; and **Side** refers to the left (L) or right (R) side of the body. These data are intended to serve as examples of the different ways Aquanex can be used to measure the same joint action. The values are not meant to represent typical or desirable measurements, but simply demonstrate the observed variability.

Peak Force (lbs) in Horizontal Adduction and Abduction at the Shoulder

Ref	Sample	Size	Surface	RSU	Action	Sex	Side	Mean	SD
1	Subjects	7	Hand	A	Adduction	F	L	11.4	3.4
1	Subjects	7	Hand	A	Adduction	F	R	11.4	5.3
1	Subjects	12	Hand	A	Adduction	M	L	20.3	7.2
1	Subjects	12	Hand	A	Adduction	M	R	21.5	8.4
1	Subjects	7	Hand	A	Abduction	F	L	4.8	1.4
1	Subjects	7	Hand	A	Abduction	F	R	5.3	2.4
1	Subjects	12	Hand	A	Abduction	M	L	9.4	3.4
1	Subjects	12	Hand	A	Abduction	M	R	9.6	4.5
1	Subjects	7	3D Ex Equip	C	Adduction	F	L	10.8	0.8
1	Subjects	7	3D Ex Equip	C	Adduction	F	R	11.1	2.2
1	Subjects	12	3D Ex Equip	C	Adduction	M	L	18.2	6.9
1	Subjects	12	3D Ex Equip	C	Adduction	M	R	19.3	7.9
1	Subjects	7	3D Ex Equip	C	Abduction	F	L	7.9	1.7
1	Subjects	7	3D Ex Equip	C	Abduction	F	R	9.0	1.3
1	Subjects	12	3D Ex Equip	C	Abduction	M	L	12.6	4.4
1	Subjects	12	3D Ex Equip	C	Abduction	M	R	14.0	4.8
2	Patients	17	Hand Paddle	D	Adduction	F	L	6.6	2.5
2	Patients	17	Hand Paddle	D	Adduction	F	R	8.5	3.6
2	Patients	22	Hand Paddle	D	Adduction	M	L	10.7	3.8
2	Patients	22	Hand Paddle	D	Adduction	M	R	13.8	5.3
2	Patients	17	Hand Paddle	D	Abduction	F	L	5.0	1.8
2	Patients	17	Hand Paddle	D	Abduction	F	R	5.1	2.0
2	Patients	22	Hand Paddle	D	Abduction	M	L	6.9	3.2
2	Patients	22	Hand Paddle	D	Abduction	M	R	7.3	2.4

REGISTRATION FORM

Name _____

Title _____

Company _____

Street _____

City _____

State _____ Country _____ Zip _____

Phone _____ FAX _____

Aquanex Products

Software - record complete version number from title screen (e.g. V 2.1 C9406) _____

Computer Interface Units (CIUs) - record serial numbers for each model received

Model DE8(D1) _____ Model DP8 _____

Model TE1(T1) _____ Model DP2 _____

Model DS1 _____ Model DS2 _____

Model DU2 _____ Model DU2V _____

Model TU2V _____

Remote Sensor Units (RSUs) - record serial numbers for each type received

Type A _____ Type B _____

Type C _____ Type D _____

To register with STR send this form to:
Swimming Technology Research, Inc.
3743 Chellowe Rd.
Richmond, VA 23225
850-385-9803
swimmingtechnology.com
info@swimmingtechnology.com

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