$$S(t)=\int_0^t \frac{\sin u}{\sqrt{2\pi u}}du=\left[v=u^2\right]=\sqrt{\frac{2}{\pi}}\int_0^{\sqrt{t}}\sin\left(v^2\right)dv$$

$$S(0)=0$$

$$\int_0^{\infty}\sin\left(v^2\right)dv=\frac{1}{2}\sqrt{\frac{\pi}{2}}$$

$$S(\infty)=1/2$$

By integration theorem:

$$S(t)\to\frac{\sqrt{\sqrt{p^2+1}-p}}{2p\sqrt{p^2+1}}$$